REPORT OF THE
IRRIGATION COMMISSION

सत्यमेव जयते

REPORT OF THE

IRRIGATION COMMISSION

1972

VOLUME I

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Ministry of Irrigation and Power
NEW DELHI

Price : Rs. 25

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PRINTED BY AROON PURIE AT THOMSON PRESS (INDIA) LIMITED, FARIDABAD, HARYANA

Ajit Prasad Jain, M.P.
Chairman

D.O. No. IC-4 (39)/72
IRRIGATION COMMISSION
(Ministry of Irrigation and Power)

New Delhi, the 30th March, 1972.

My dear Dr. Rao,

Second in sequence, our Report is being presented to the Union Government almost seventy years after the report of the First Irrigation Commission in 1903. During the intervening years there has been a tremendous growth in irrigation engineering and irrigation concepts. The Mettur Dam built in the 'thirties was the first concrete dam to be built in India. India was not producing cement at the time, and it had to be imported from abroad. Beginning with the Hirakud and the Damodar Dams, the use of earth-moving machinery during the last 25 years has made spectacular progress in the construction of earth dams and excavation of canals. Tunnelling for the conveyance of water came into vogue.

2. The exploitation of deep aquifers by drilling tubewells several hundred metres below the earth's surface is a recent concept in irrigation. The Geological Survey of India and the State Departments of Geology have made fairly extensive surveys of ground water resources—though much remains to be done. The advent of electricity for lifting water from tubewells and from surface sources through high capacity and high lift pumps has opened possibilities of irrigating areas beyond the reach of surface flow.

3. The aerial survey and the aerial photography of catchment areas and irrigation commands have made possible the speedy execution of irrigation projects. The concept of ayacut development, which began in the Tungabhadra Project completed in the early 'fifties, is now generally accepted in all irrigation projects. The science of soil-plant-water relationship has gained new impetus.

4. An important feature of our recommendations is the need for the conjunctive use of ground and surface waters, preparation of complementary programmes covering engineering works, water-shed manage-

ment and ayacut development. The machinery proposed for the purpose would be the seven River Basin Commissions for the whole country, which will deal with about 20 major rivers.

5. We were commissioned to make special proposals for irrigation works in the chronically drought affected and food scarcity areas. As we proceeded in our work we found that the difference between the chronically drought affected and drought affected areas was only one of degree. The chronically drought affected areas are extremely limited and found only in the States of Rajasthan and Gujarat. We decided, therefore, to ignore the distinction between chronically drought affected and drought affected areas and accepted a larger definition covering both.

6. The concept of food deficit areas with the modern development of transport and communications has become irrelevant. It is not necessary for every area to produce its own food. Some areas of scanty rainfall such as the Jaisalmer region of Rajasthan or the Banni area of Gujarat must of necessity be devoted to sheep and cattle raising. When we posed a question to the experts of Indian Agricultural Research Institute asking them what programme of irrigation they would suggest for areas like Jaisalmer and Banni, they readily replied : "Leave them to sheep and cattle raising".

7. We were required to suggest the minimum works necessary for the drought affected areas to make them self-sufficient. The perspective programme suggested by us would increase the irrigated area to 50 per cent of the cultivated area for the country as a whole. The maximum development of irrigation in drought areas is not likely to increase it above the range of 25 per cent of the cultivated area. Keeping in view the social urges and the demand for the removal of regional and social disparities which are basic to establish socialism, we decided that the development of irrigation in the drought affected areas should be the maximum. Even so these areas will have only half the percentage of the average irrigation of the country.

8. The minor irrigation works have a special relevance to the drought affected areas and we have suggested that the programme of constructing minor works should be completed within the next ten years. They supplement the canal irrigation and fill the deficiencies of large irrigation works.

9. Many of our existing irrigation works, which were by all standards a creditable performance at the time when they were executed, are now proving too inadequate to meet the exacting demands of the new high-

yielding varieties of crops. These crops require not only timely irrigation but also irrigation in the required quantities. We have suggested measures to improve the irrigation capacity of these works to meet the requirements of new crops.

10. We have made proposals for streamlining procedures to expedite and facilitate construction of irrigation works. The proposed Directorate of Hydrology will make available the hydrological data for the river basin plans and major irrigation projects. The use of computers for the collation of irrigation and agricultural statistics will provide the latest material to irrigation planners. If the Union Irrigation Ministry plays a dynamic role in settling inter-State disputes of the kind the World Bank did in the Indus water dispute between India and Pakistan, delays inherent in procedures followed by courts and tribunals will be cut down.

11. The most important among our major recommendations is the one relating to a Water Resources Council. In a federal set up, such a body becomes necessary to harmonise regional and national interests, to establish smooth relations between State and State and between the Union and the States, and to ensure an integrated development of irrigation.

12. The gigantic programme of irrigation works envisaged by us for completion by the end of the century will roughly cost the nation 100 billion rupees. It will more than double our irrigated area, that is raise it to 81 million hectares or to 50 per cent of the sown area. This irrigation would, in our opinion, be needed to meet full needs of food and fibre requirements of the nation at that period of time. Judging from previous allocations and progressively higher allocations from one Plan to another, we think, that it should be possible to undertake financing of that order within the next 25–30 years.

13. In order that irrigation in India should pay for itself, it is imperative that the water rates be raised to a level sufficient to cover the cost of maintaining and running the works and a reasonable rate of interest on investment. We see no reason why a beneficiary from irrigation should not be made to contribute to the public exchequer a part of the increase in the value of land achieved at social cost. For that purpose, we have suggested the imposition of a betterment levy and have linked it with the cost of the project to reduce chances of litigation. The levy of rates on lands benefited from drainage and flood control measures, is in our opinion, fully justified.

14. There are prophets of doom who ask : "What will happen to our country after the capacity of our reservoirs is exhausted?" At the present rate of sedimentation some of the reservoirs may silt up much earlier than planned. But we have no serious apprehension in our mind about the future soil conservation measures, suggested by us, would help prolong the life of the reservoirs. The large resources of ground water in any event are not going to be affected. There is also the possibility of increasing ground water recharge through new processes. Desalinisation, though now too costly and a distant possibility for irrigation, cannot be ruled out as a feasible proposition with the development of new sources of energy.

15. The science of seeding clouds has made some progress in foreign countries though not much in India, but the creation of moisture bearing clouds by scientific methods and directing their movement is within technological possibility in the age of man's landing on the moon. And lastly, the Himalayas have inexhaustible reserves of snow and through the use of atomic energy, it may be possible to melt this snow to meet occasional shortages in snowfed rivers and reservoirs.

16. We have laid emphasis on the inter-valley transfers of water. The water of the mighty Brahmaputra is hardly being utilised in its flow through our country. It should some day be possible to divert some water of the Brahmaputra to West Bengal and other States. The Ganga-Cauvery link has been certified to be technically feasible by the experts from the United Nations. Its economics are going to be studied soon. We see no reason why a country-wide irrigation grid should not be treated as feasible.

17. The tremendous amount of work involved in collecting, sifting and scrutinising the voluminous data, classifying and using it for the purpose of the Report, would not have been possible but for the unflinching cooperation and support of the Members and Consultants of the Commission. They have worked hard and ungrudgingly. For the recommendations of the Report, they and I bear equal responsibility.

18. Most of the State Governments have rendered us unqualified cooperation. They set up special cells for the collection of the material asked for. We are grateful to the State Governments and their officers for helping us in our work and for making our visits to the States easy and comfortable.

19. I take special pleasure in acknowledging the services of the

National Atlas Organisation and the Survey of India in preparing the first Irrigation Atlas to be published in the country. This Atlas will supply reliable and important basic data to thousands of engineers working on irrigation projects.

20. The Indian Law Institute, which collected material and prepared a draft for the chapter on Irrigation Acts and Codes, deserves my special thanks.

21. The Central Water and Power Commission and the Irrigation and Agriculture Ministries of the Union as also other departments have assisted us in our difficult task. I offer them sincere thanks.

22. The large number of Heads of Departments, district officials and farmers who met us and gave valuable advice are also deserving of gratitude. So are the universities, research institutes and stations and experimental and demonstration farms which have supplied us with material.

23. The Directors, Private Secretaries, Stenographers and other officials who formed the invisible back-bone of the Commission deserve a tribute for their untiring labours.

24. Even at the risk of being accused of making an invidious distinction, I must record my appreciation of the services of Shri K.S.S. Murthy, our Member-Secretary, whose contribution throughout has been outstanding.

25. I am grateful to you for your help and advice on numerous problems with which we were confronted at various stages of our work.

With best wishes,

Yours sincerely,

(Ajit Prasad Jain)

Dr. K.L. Rao,
Union Minister of Irrigation & Power,
New Delhi.

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PART II

CHAPTER I

INTRODUCTION

The dependence of India's agriculture, on the south-west monsoon and its consequent vulnerability have been recognised from the earliest times. Since agriculture has always been the principal occupation of the vast majority of the people, successive rulers whether Hindu, Muslim or British, have directed their energies to improving the lot of the farmer. To give him some protection against the failure of the rains, they brought water to his fields from rivers, streams and tanks. These efforts were supplemented by the hundreds of thousands of wells dug by the farmers.

1.2 These early irrigation ventures, however, were concerned largely with impounding rain-water in tanks, and with leading canals from these tanks to the parched land. There were one or two notable exceptions like the Cauvery Delta System and a few inundation and diversion canals from rivers. However, all these sources together could irrigate only a fraction of the vast areas under crops, and agriculture continued to depend on rain.

1.3 The 19th and early 20th centuries witnessed the flowering of the art of irrigation in India. Old canal systems were improved or renovated and new and more elaborate canal systems were constructed. Permanent headworks were put up on many of the great rivers. Some of these irrigation works were models of their kind, such as the Godavari and the Krishna Delta Systems, the Upper Ganga, Agra and Sone Canals; the Cauvery-Mettur Project; the Nizamsagar and the Krishnarajasagar dams; the Sutlej Valley Canals and the great Sukkur Barrage. They provided protection to vast areas.

1.4 The partition of India in 1947 involved not merely the physical division of the sub-continent into the two territories of India and Pakistan, but a division of assets as well. In the process, India's predominantly agricultural economy was dealt a severe blow. Although, we were left with 80 per cent of the pre-Partition population, we lost 31 per cent of the irrigated area on which the country had largely depended for cereals,

fibres and oilseeds. Nearly half of 11,340 cumecs (400,000 cusecs) of water carried by all the canals of India before Partition fell to the share of Pakistan. Within the command of the Indus System, 8.5 million hectares (21 million acres) of irrigated land went to Pakistan, as against only 2.1 million hectares (5.1 million acres) which were left with India. Some of the most impressive of the country's projects, like the Sutlej Valley Project which still ranks among the largest irrigation systems in the world, and the unique Sukkur Barrage across the Indus in Sind, with its extensive systems of canals, fell to the share of Pakistan. The loss of these major irrigation systems made an immediate and disastrous impact on India's already critical food problem, resulting in a deficit of four million tonnes in 1947.

1.5 Drought and the war-torn economy of India caused a massive deficit in food supplies, and the immediate requirement in 1947, to maintain even a very inadequate minimum ration, was four million tonnes.

1.6 The world was passing through a crisis on the food front in 1947. The dislocation of the economy of many countries, as a result of the Second World War, and severe droughts affecting many parts of the world had led to an unprecedented food shortage. The period from July 1946 to June 1947 was a period of global scarcity. World food production was 12 per cent below the pre-war figure and in Europe it was 25 per cent below. The world wheat deficit amounted to seven million tonnes. The rice crop in Asia, which accounted for 95 per cent of the world's total rice production, was 15 per cent below normal. Had it not been for the combined efforts of Prime Minister Attlee of Great Britain and President Truman of the United States of America, and the willingness of wheat-producing countries to reduce the level of their own consumption so as to increase exports of foodgrains to deficit countries, a disaster as great as the Bengal Famine of 1942 might well have occurred in India.

1.7 India was, therefore, ill prepared to suffer the drastic reduction of irrigation water which resulted from Partition, particularly when large areas of cultivated land had been left fallow, because of the cross-movement between India and Pakistan of millions of refugees.

At this time, some irrigation projects had been investigated and a few were under construction.

1.8 When the era of planning began in 1951, great emphasis was naturally placed on irrigation, and this planned effort has met with great success. From 22.6 million hectares (56 million acres) irrigated from all sources at the beginning of 1951, the figure went up to 37.5 million

hectares by 1969. The potential of major and medium irrigation went up from 9.7 million hectares to 18.5 million hectares and of minor irrigation from 12.9 million hectares to 19.0 million hectares. Of the 537 major and medium irrigation projects taken up for construction, 300 or more have been completed. The total allocation for irrigation projects in the first three Plans and in the three years of the Annual Plans, amounted to Rs. 17,557 million. Among the works undertaken were gigantic schemes like the Bhakra Dam and the Bhakra Nangal Multi-purpose Project, the Rajasthan Canal Project and the Chambal and Nagarjunasagar Projects, to mention only a few. As against approximately 93,745 m.cu.m (76 M.A.F.) of water used in 1951, the utilisation at the end of 1969 had risen to 204,758 m.cu.m (166 M.A.F.).

1.9 In the drought years of 1965 and 1966, famine in large tracts of the country was averted only by massive administrative efforts and huge imports of foodgrains. These years brought into focus the importance of the role of irrigation. Although the irrigated area had been doubled since Independence, it was clear that greater efforts were needed if the country was to keep pace with the rising demands of a rapidly increasing population. The birth-rate remained more or less steady during the years 1951 to 1971, but the reduction in the death-rate during this period resulted in a population explosion. The rising demand for food, fibres and oilseeds led to shortages. The advent of high-yielding varieties of crops which involve more exacting water regimes, and the progressive use of fertilizers make it more important than ever to develop the utilisable water potential and to increase the efficiency of irrigation.

1.10 New areas could not be brought under crops without encroaching further upon India's already inadequate and depleted forest resources. The answer lay in the intensive cultivation of existing arable land, rather than in the extension of cultivation to new areas. In particular, the urgency of solving both the food and water problems of drought affected and scarcity areas was widely recognised, because it was precisely these pockets which made intensive demands on the country's food stocks.

1.11 Any major leap forward in the field of irrigation would necessarily involve heavy investments, because most of the "run-of-the-river" schemes had already been tapped by weirs and other diversion works, and by inundation canals. New irrigation schemes would involve the construction of storage dams at difficult sites.

1.12 In the circumstances, what was urgently required was an examination of the present status and the future prospects of irrigation, to

assess what had been done and what more could be done. A survey of this nature would enable the Union Government, as well as the State Governments, to gain an all-India perspective of the problem, so that they could plan for the future expansion of irrigation, secure in the belief that whatever schemes were launched would fulfil the country's most urgent requirements, and that whatever priorities were fixed were realistic and justifiable. Some important schemes for storage on inter-State rivers bristled with economic, financial and political difficulties and have been held up for one reason or another. An all-India perspective could only be had by adopting the river-basin approach to irrigation. So far, with perhaps the exception of the Damodar Valley Project, no irrigation system in India had been built on the basis of an integrated study of a river valley.

1.13 There was also a need to review the working of existing schemes, to determine how far they could meet the requirements of new crops and cropping patterns, and how their efficiency could be improved. It was common knowledge that many existing irrigation schemes had suffered heavily from a variety of causes, including faulty headworks, the silting up of reservoirs, seepage from canals and water courses, and inadequate drainage. On some projects, the causes of the inadequate utilisation of water and the failure to develop the command areas remained to be discovered. The ills which have beset so many projects could be cured only by introducing modern concepts of water-shed and water management, soil conservation and drainage, by modernising and streamlining canal systems, and by putting up reservoirs.

1.14 Finally, there was the problem of using ground water to the best advantage, and of promoting the conjunctive use of ground and surface water, not only in order to bring larger areas under irrigation but also to stabilise irrigation in existing areas. The use of ground water is not only beneficial to drought-affected and scarcity areas, but helps to keep down the water-table in areas of high rainfall. The conjunctive use of surface and ground water needed to be studied in its diverse aspects.

1.15 The First Irrigation Commission of 1901–03 was appointed in the shadow of two famines which had highlighted the need to extend irrigation as a protection against future famines. Our Commission was set up in the context of a rapidly expanding economy and an even more rapidly expanding population, and in the wake of rapid advances in agriculture, aptly called "The Green Revolution". The emphasis has now shifted from the protective use of irrigation, to irrigation as a means of attaining greater production of food, fibres and

oilseeds. Irrigation development must necessarily play a very important role in India's quest for self-sufficiency.

The First Irrigation Commission

1.16 The wide-spread suffering caused by successive famines in the closing decades of the 19th century led to the setting up of a series of famine commissions. The first commission was appointed in 1878. It made several suggestions on the basis of which the famine codes were promulgated from 1883 onwards.

1.17 The Second Famine Commission was set up after the drought of 1896–97. It recommended that "Among the measures that may be adopted for giving India direct protection from drought, the first place must unquestionably be assigned to works of irrigation." In the terms of reference to the First Irrigation Commission, the Government of India fully endorsed this view.

1.18 The various famine codes had dealt with the methods and the administrative machinery to be used both before and during a famine, to avoid extreme distress. According to the codes, the crux of the system for dealing with the conditions created by drought and famine was the opening of famine relief works, to provide employment to large numbers of unemployed people. Prominent among such works were the digging of new tanks and the repair of existing tanks. Only after the appointment of the First Irrigation Commission were more ambitious construction programmes taken in hand as famine relief works.

1.19 The First Irrigation Commission, according to a Resolution of 13th September, 1901 of the Governor General-in-Council, was required, inter alia—

(i) To ascertain the utility of irrigation under local conditions of agriculture, whether in generally increasing the produce of the land or in securing it from the effects of failure of rainfall.

(ii) To report upon the extent to which irrigation has been provided by works constructed by the State and the results—productive, protective, and financial—which have been attained.

(iii) To determine the scope which exists for further extensions of State irrigation works......

(iv) To consider the extent to which local capacities for irrigation have already been utilised by private individuals......

1.20 The Commission presented its report on April 11, 1903. It is

a most interesting and readable document and a tribute to the wide-ranging knowledge, intelligence and understanding of its authors.

1.21 The Commission declared that "There were obvious limits to the permanent charges which the State may reasonably be expected to meet for the purpose of increasing the produce and profits of cultivation in particular tracts." Accordingly, it laid down a set of criteria for judging the feasibility of proposals for irrigation works, subject of course to the all important reservation that there could be no limit to expenditure where human life and safety were involved.

1.22 The Commision took into consideration such factors as the estimated total cost of famine relief works in a tract for the preceding 25 years; the population of the tract; the per capita area which should be protected by irrigation, and the area already protected. After weighing these factors, it concluded that Government should be prepared to face an expenditure equal to three times the future annual cost of famine relief and remissions of revenue, for the sake of preventing famine altogether. According to the Commission, protective works could be sanctioned, without hesitation, when the capital cost was not likely to exceed thirty times the net revenue, or whenever a net return of three per cent on the actual outlay could be anticipated.

The Present Irrigation Commission

1.23 The present Commission was set up by the Government of India in the Ministry of Irrigation & Power, by a Resolution No. DW. II-28 (52)/67 dated the 1st April, 1969. The Resolution reads as follows:

> "Since Independence the country has made substantial progress in irrigation development. The area under irrigation has been nearly doubled from what it was at the time of Independence. Even so, about four-fifths of the country's cultivated area still depends exclusively on rainfall. The drought conditions in the last four years in several parts of the country and the continued food shortages have brought into sharp focus the importance of providing greater irrigation facilities. In this context the maximum exploitation of both surface and ground water resources within the next four to five Plan periods needs greater emphasis and attention. The Government of India have, therefore, decided in consultation with the State Governments and Administrations of Union Territories, to set up an Irrigation Commission to go into the question of future irrigation development in the country

in a comprehensive manner. The composition of the Commission shall be as follows:

Shri Ajit Prasad Jain, Member of Parliament.	..	Chairman
Dr. S. R. Sen, Additional Secretary, Planning Commission.	..	Vice-Chairman
Shri O. P. Gupta, Retd. Chief Engineer, Irrigation, Uttar Pradesh.	..	Member
Another irrigation engineer to be nominated later.	..	Member
Shri D. V. Reddy, Extension Commissioner, Department of Agriculture.	..	Member
Shri N. S. Pardasani, Secretary, Irrigation & Power Deptt., Maharashtra, Bombay.	..	Member (Part-time)
Shri K. S. S. Murthy, Officer on Special Duty, Ministry of Irrigation & Power.	..	Secretary ....”

Shri K. V. Ekambaram, Retired Chief Engineer, Irrigation, Government of Tamil Nadu, was appointed as Member on the 8th September, 1969.

On his appointment as Executive Director of the International Bank for Reconstruction and Development, Dr. S. R. Sen left us in June, 1970. Shri L. J. Johnson joined as Vice-Chairman on 14.1.1971.

Shri N. S. Pardasani, part-time Member, resigned on 29th January, 1970. Shri K. S. S. Murthy was appointed as Member-Secretary with effect from 5th December, 1970.

Shri Balwant Singh Nag, former Adviser to the Planning Commission was appointed as a Consultant in February 1970 and participated fully in the Commission's deliberations.

1.24 The terms of reference of the Commission were as follows:

(1) To review the development of irrigation in India since 1903, when the last Irrigation Commisssion submitted its recommendations, and report on the contribution made by irrigation to increasing the productivity of land, and in providing insurance against the vagaries of rainfall.
(2) To examine in detail the irrigation facilities available in chronically drought affected and food deficit areas, and suggest essential and minimum irrigation works to be undertaken promptly in such areas.
(3) To draw up a broad outline of development of irrigation of all types, for achieving self-sufficiency in cereals, and for maximising the production of other crops, and to make a broad assessment of the funds required for the purpose.
(4) To examine the adequacy of water supply in major irrigation projects.
(5) To examine the administrative and organisational set-up for the planning, execution and operation of irrigation works, particularly with a view to the speedy completion of projects, and reduction of their gestation period.
(6) To suggest criteria for the sanctioning of irrigation projects and
(7) To examine any other matter incidental or related to the development of irrigation in the country, and make suitable recommendations.

1.25 A meaningful irrigation policy can have several objectives, but undue emphasis in favour of any one of them may seriously prejudice the others. If India's irrigation policy were to have the single objective of maximising the production of food and other crops to attain self-sufficiency, this objective, in the context of modern agricultural technology, could be attained by making massive investments in irrigation only in those areas where the possibilities of producing crops are maximum per unit of water. However, the wide differences in terrain, climate, rainfall and sources of irrigation, which lead to economic disparities between regions, call for a different approach. One-third of the country suffers from drought and scarcity. Large areas of undulating country within the drought zone require heavy investments on land-shaping and land-levelling to permit effective irrigation. The cost of irrigation per hectare in the drought zone, therefore, is higher than elsewhere. Nevertheless, even if all the water resources of these areas are harnessed for irrigation, the total area irrigated would still come to only 50 per cent of the average for the country.

1.26 It is clear, therefore, that a meaningful irrigation policy for India must have several objectives. It must aim at increasing the production of foodgrains and fibres etc., at providing protection to vulnerable areas against the vagaries of rainfall, and at bringing irrigation to drought affected areas. Such a policy must also be in consonance with the declared national objectives of a socialistic pattern of society. We feel that it would not be in consonance with such a pattern to concentrate our irrigation effort in areas with the most favourable climatic, soil and topographical conditions, even though such an effort would cost less and would certainly give a substantial increase in production, if this meant postponing irrigation indefinitely in less favoured areas, where the agricultural population is carrying on a precarious form of subsistence agriculture. If our national policy is to reduce the economic gap between one section of the people and another and between one region and another, we must orient our objectives to achieve this end. We cannot, therefore, in the name of self-sufficiency afford to widen the gap between the poorer agriculturists in drought affected areas and the wealthier agriculturists in areas of agricultural plenty. Nor in the name of reducing disparities, can we concentrate our irrigation effort in drought affected areas, if the economic returns are so low as to be completely unjustifiable.

1.27 Within the limitations imposed by the facts of topography, soil and climate, we have endeavoured, in our recommendations, to suggest policies which will maintain a balance between several objectives which are expressly, or by implication, included in our terms of reference. We have kept in mind the objective of maximising production through effective irrigation, but have not lost sight of the equally important objective of reducing regional disparities and of protecting the weaker sections of our society.

1.28 Soon after our office was set up, we issued in August, 1969 an exhaustive Questionnaire to the States to elicit information on various aspects of irrigation development, progress and programmes, policies and the future needs and expectations. We also requested the States to send us Preliminary Memoranda embodying their views on the several issues to be considered by the Commission.

1.29 Thereafter, Members of the Commission visited State capitals to expedite replies and to furnish clarifications whenever they were required. Replies to the Questionnaire started coming in from January, 1970 and the last batch was received in December, 1971.

1.30 The Commission toured the States from April, 1970. The visits

in each State lasted from five to ten days. Some of the bigger States had to be visited twice, one region being covered in the first visit and another in the second. Normally the tours were undertaken after the States had sent their replies to the Questionnaire and the material had been studied in the Commission. We visited the sites of a number of irrigation works, saw the areas under irrigation; we also saw a number of projects under construction and the areas proposed to be irrigated by these projects. Visits were also made to quite a few important projects under investigation. Also, during the tours, meetings were held at important towns and villages with progressive farmers, Members of the State Legislature, Members of Parliament and district officials. At these meetings, the scope of the Commission's work was explained and there was a free exchange of views and ideas on irrigation development. In addition to these formal meetings, a number of visits to farms, road-side meetings and discussions with individuals were held. Discussions were also held at the State Headquarters, initially at the official level and later with the Chief Minister and Ministers. We found that everywhere the Chief Minister and his colleagues, the people, the M.Ps, the M.L.As, and the district officials were full of enthusiasm and eager to assist us with valuable suggestions. Some of our tours were delayed or postponed on account of the General Elections in 1971. This led to a set-back in our programme of work but it was soon made up. There were delays in receipt of some replies, but on the whole the response of the States to our Questionnaire was very satisfactory and the replies were informative and useful.

1.31 Advantage was also taken of the visits of State Government officers to Delhi for discussions on specific points of interest. We invited experts from the Indian Agricultural Research Institute, the Director-General, Geological Survey of India, the Central Water & Power Commission (CW&PC) and the Ministry of Agriculture for discussions. In the course of our tours we visited a number of Agricultural Research Institutes, Universities and Irrigation Research Stations. We had very useful and detailed discussions at the Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jubbalpur, the University of Roorkee and the Rice Research Institute, Cuttack. We had the benefit of a discussion with the Union Minister of Irrigation & Power. In our report we have drawn freely on these discussions, memoranda, replies to the Questionnaire and our observations on tours.

PART I

INDIA—PHYSICAL AND OTHER FEATURES
LAND AND WATER RESOURCES
PROGRESS OF IRRIGATION

सत्यमेव जयते

CHAPTER II

INDIA—PHYSICAL AND OTHER FEATURES

PHYSIOGRAPHY

Location and Size

Lying between 8°4 and 37°6 North latitude, and 68°7 and 97°25 East longitude, the land mass which forms the sub-continent of India, covers an area of 328 million hectares and supports a population of 547 millions (1971). With a land frontier of 15,200 kilometres and a coastline of 5,700 kilometres, it is the seventh largest country in the world.

Major Landforms

2.2 The diversity of landforms in India is matched by the diversity of its climate, its peoples and its cultures. Towering mountain ranges, rolling hills, lofty plateaus and extensive plains, have all played their role in shaping the physical features of the sub-continent and its cultural, economic and political history.

The Mountains

2.3 The mountains of India are the cradle of its streams and rivers. They collect and channel the rain and snow precipitated on their slopes and summits. They affect its climate and rainfall. All the characteristics of a mountain system its mean elevation, its trend, its slope and its geology —influence the hydrology of the rivers which flow from it. The great mountain system of the Himalayas exercises a dominant and generally benign influence on the climate of north India.

The other major mountain ranges of India are Aravallis, the Vindhyas, the Satpuras, the Eastern and Western Ghats, and the North-eastern ranges.

The Himalayas : The Himalayas, which tower above the great plains of India in the north, are the youngest of the world's great mountain systems and one of the mightiest. They stretch in a virtually unbroken

chain, as a series of more or less parallel, though sometimes converging, ranges from the Indus in the west to the Brahmaputra in the east. The chain consists of three, more or less parallel series of ranges: (i) the Great Himalaya (average height 6,000 metres) which contains, among a host of other peaks, the famous peaks of Everest (8,848 metres), Kanchenjunga (8,598 metres) and Nanga Parbat (8,126 metres); (ii) the middle Himalaya (average height 3,200 to 4,500 metres) and (iii) the outer Himalaya or the Siwalik foot hills (average height 900 to 1,200 metres), through which the Himalayan rivers finally debouch into the plains.

The Aravalli Range : The Aravalli range is the oldest mountain range in India. It stretches for a distance of about 800 kilometres south-westwards from Delhi. The ravages of time have left only a handful of peaks, including Mount Abu (1,158 metres), the rest having been reduced to low, rugged hills and ridges, except for the Mewar range.

The Vindhya Range : The Vindhya range (1,050 kilometres) traverses almost the whole width of peninsular India. Together with the Satpura range (900 kilometres) which runs more or less parallel to it, the Vindhya range forms one of the country's major water-sheds dividing north India from the Deccan. While the average elevation of the Vindhyas is only 300 metres, several of the peaks in the Satpuras rise above 1,000 metres, and for the greater part of its length the average height of this range is above 500 metres.

The Western Ghats : The Western Ghats extend 1,600 kilometres from south of the Tapi valley to Cape Comorin at distances from the sea-coast which vary from 150 kilometres in Sagar to 80 kilometres in Coorg. The most significant feature of the Ghats is that they give birth to all the important rivers of peninsular India with the exception of the Narmada and the Tapi. These rivers flow eastward into the Bay of Bengal, though their sources lie a mere 50 to 80 kilometres from the Arabian Sea. The average elevation of the Ghats in the north is about 550 metres, with a few peaks rising to 1,000 metres. South of Bombay, the average elevation is 1,400 metres rising at Mahabaleshwar to 1,438 metres and at Kalsuba to 1,646 metres. Further south in Coorg, the peaks rise to more than 2,500 metres.

The Eastern Ghats : The Eastern Ghats border the plateaus of the Peninsula on the east, and consist of a series of ranges and spurs cut into discontinuous blocks of hills by large rivers flowing to the sea. They run more or less parallel to the coast, though receding at intervals, leaving broad plains which stretch from their base to the coast. They reach their most imposing proportions in the region north of Vishakapatnam between the Mahanadi and the Godavari, where they form the watershed of several major rivers flowing into the Godavari. As they

near the Krishna valley, the Ghats grow less and less imposing; but as they approach the point where they meet the Western Ghats, they recover some of their grandeur. Some peaks in this area rise to more than 2,550 metres.

The North-eastern Ranges : The North-eastern ranges which include the Garo, Khasi and Jaintia hills constitute the Meghalaya plateau with an average elevation of 830 metres. The plateau slopes northward in a series of steps down to the valley of the Brahmaputra.

Plateaus

2.4 Plateaus are a prominent feature of the Indian topography. They range in elevation from 300 to 900 metres, and their flanks form usually steep, and occasioally spectacular, scarps. The surface of the plateaus sometimes consists of extensive plains, either flat or undulating, broken by conical or rounded hills or flat-topped ridges. Among the more noteworthy and distinctive plateaus, are those of the Malwa, the Vindhya, the Chhota Nagpur (Ranchi, Hazaribagh and Kodarma), the Satpura (Betul and Maikala), the Deccan (Maharashtra, Karnataka and Telangana), Ladakh and Meghalaya (Shillong).

Plains

2.5 A very large part of the sub-continent consists of extensive plains watered by great rivers, and supporting enormous populations. As is to be expected, they vary in extent and characteristics, and include almost all known types. They comprise the vast aggradational Indo-Gangetic plains, the coastal alluvial and lava plains, the mountain plains (lacustrine and glacial) such as the Kashmir valley, the Imphal basin and Ladakh, the piedmont plains at the foot of the Himalayas (bhabar and duar), the pediplains of south India and the peneplains which crown the summits of the Shillong plateau and the hills of the Nilgiris.

Physiographic Divisions

2.6 Physiographically, India can be divided into seven divisions and twenty sub-divisions as shown in Plate 3 of the Atlas. (1) The Northern Mountains; (2) The Great Plains; (3) The Central Highlands; (4) The Peninsular Plateau; (5) The East Coast Belt; (6) The West Coast Belt; and (7) The Islands.

The Northern Mountains

2.7 The Himalayan range, 2500 kilometres in length and 250 to 400 kilometres in width, with a mean elevation of 6,000 metres in the central axial range, is the dominant geographical feature of India. It is a complex of several parallel and converging ranges intersected by enormous valleys and extensive plateaus.

From the Pamirs in the north-west to the trijunction of India, China and Burma in the east, the Great Himalayan range is drained by a multitude of streams and rivers. It is also pierced by many passes few of which are at heights less than 5,000 metres.

The Great Plains

2.8 Stretching across hundreds of kilometres at the feet of the Himalayas, the great Indo-Gangetic plains have been built up in the west by the Indus and its tributaries, and in the centre and east, by the Ganga and its tributaries. Arid, semi-desert and desert conditions characterize those portions of the great plains which lie in the southern portion of the Punjab and the Thar desert of Rajasthan.

The northern limit of the alluvium-filled trough forming the great plains is well-defined, but the southern boundary follows the crenellated line of the central highlands.

The thickness of the alluvium varies greatly from area to area, and is the greatest in the Ganga plains and the least in the western plains.

Of the total 652,000 sq. kilometres of the great plains, as much as one-third lies in the arid zone of western Rajasthan; another one-third in Uttar Pradesh; Punjab, Bihar and West Bengal account, in more or less equal proportions, for the remaining third. Between the Himalayan foothills and the great plains lie two distinctive belts of territory known in Punjab and U.P. as the 'bhabar' and the 'tarai'. The first is a piedmont plain in which coarse pebbles are inter-mixed with finer and extremely pervious detritus where the smaller Himalayan rivers and streams vanish underground, till they emerge in the 'tarai' which is a marshy tract on the northern edge of the great plains.

The alluvium which forms the great plains was laid down during successive geological eras, but the older alluvium, (locally known as 'bangar') forms the higher ground, while the newer alluvium (called 'khadar' in U.P. and 'bet' in Punjab) forms the flood-plains, adjacent to the rivers.

The regional slopes of the great plains are mainly towards the south-east and south-west, and their general configuration has been determined by the mountains which lie to the north, to the west, and to the east.

The surface of the great plains is at tide level near the mouth of the Ganga, but is well over 200 metres above sea-level in the Punjab plains.

The Central Highlands

2.9 Between the great plains of north India and the plateaus of the Deccan lie the Central Highlands, consisting of a wide belt of hills bordered in the west by the Aravalli range and in the east by a steep escarpment. They form a compact block of mountains, hills and plateaus intersected by valleys and basins largely covered by forest and account for one-sixth of the total area of India.

The northern part of the highlands contains the Aravalli range, the east Rajasthan uplands, the Madhya Pradesh pathar, and the Bundelkhand upland, while the southern part contains the Malwa plateau, the Vindhyan scarplands, the Vindhyan range and the Narmada valley.

The Peninsular Plateaus

2.10 The peninsular plateaus between the Bay of Bengal in the east and the Arabian Sea in the west constitute the largest of the physiographic divisions of India.

From north to south, the distance between Pachmarhi and Cape Comorin is 1,600 km; and west to east from the Western Ghats to the Rajmahal hills it is 1,400 km. Though the plateau surface rises to over 1,000 km. in the south, it hardly ever exceeds 500 km. in the north.

The area is triangular in shape, with its apex near Broach and its base extending along the Eastern Ghats from Cape Comorin to Rajmahal in Bihar. The other two sides of the triangle are formed by the Western Ghats and the Satpura range, respectively.

The peninsular plateaus consist of five physiographic sub-divisions—the Western Ghats, the North Deccan Plateau, the South Deccan Plateau, the Eastern Plateau and the Eastern Ghats. These areas are mainly drained by the east-flowing Godavari, Krishna and Cauvery, and by the west-flowing Tapi.

The East Coast Belt

2.11 The east coast belt is washed by the waters of the Bay of Bengal. It extends for a distance of 1,000 km. from Cape Comorin northward to the united delta of the Krishna and the Godavari, with an average width of 100–130 km. The belt almost vanishes at the point where the Eastern Ghats, known here as the Mahendra Giri, come down to the

coast. Further north, it again widens as it extends across the Chilka lake, the Mahanadi delta and the Balasore coastal plains to merge with the deltaic plains of the Ganga.

The West Coast Belt

2.12 The west coast belt which is washed by the waters of the Arabian Sea, runs more or less straight from Cape Comorin to Broach, for a distance of 1,500 km. The coastal plains are confined to a narrow belt 10–25 km. wide between the Western Ghats and the sea. The two peninsulas of Kathiawar and Kutch, and the wide Gujarat plains are at the northern ends of this coast.

The Islands

2.13 The islands of India lie in the Arabian Sea and in the Bay of Bengal. In the Arabian Sea, are the coral islands of the Laccadive, the Amindivi and the Minicoy, and in the Bay of Bengal, the Andaman and Nicobar Islands which are formed by the elevated portions of submarine mountains rising above the sea.

Forests

2.14 The area under forests in India is 63 million hectares which is 20.5 per cent of India's total geographical area. The National Forest Policy which was enunciated in 1952, lays down that India, as a whole, should aim at maintaining one-third of its land under forests. It was considered essential to maintain a higher percentage of land under forest in mountainous regions for protection against erosion, floods and denudation. Accordingly, in the Himalayas, and other mountainous areas the aim should be to raise the percentage of land under forest to 60 per cent. In the plains, where the pressure of population and the demand for cultivated land is the greatest, the area under forest could be as low as 20 per cent, but not less. Based on the 1971 figures, the per capita forest area is 00.11 hectares (00.28 acres).

The most densely forested area in India lies in the Andaman Islands where over 90 per cent of the total reporting area of 6,480 sq. km. is forest. The high quality and the great variety of timber in these islands has long been famous. Next comes Jammu and Kashmir with 61.4 per cent, followed by Madhya Pradesh (33.1 per cent), Assam (29.9 per cent) and Kerala (27.4 per cent). The States with the lowest percentage are Gujarat (8.8 per cent), Rajasthan (3.4 per cent), Haryana (2.1 per cent) and Punjab (1.6 per cent).

Main Rivers

2.15 The river systems of India can be classified in two groups, viz., the perennial rivers of the Himalayan region and the rivers of peninsular India. The former which are fed by the melting snows and glaciers of the Great Himalayan range, are often uncertain and capricious in their behaviour. Some of these rivers are meandering in their flow, or subject to drastic changes of course, particularly after landfalls and earthquakes caused by seismic activity in the region.

The peninsular rivers originate at much lower altitudes, and flow through areas which are geologically more stable. They are more predictable in their behaviour.

The flow patterns of the two groups of river systems are markedly different. In the peninsula, the flow is characterized by heavy discharges during the monsoons, followed by low discharges during the rainless months. Variations of the order of 1 to 300 in the mean monthly flows of these rivers are common.

In the Himalayan river system, the dry weather flow is significantly enhanced by water from the melting snows and glaciers. The lean period for these rivers is the winter, but at no time is the flow so reduced as in the peninsular rivers.

Drainage System

2.16 The drainage system of the Himalayas reflects its geological history. The Himalayas are of comparatively recent origin, and there is clear evidence that many of the great rivers like the Indus, the Sutlej, the Alaknanda, the Bhagirathi and the Brahmaputra were flowing before the Himalayas were born. It is this circumstance of antecedent drainage which explains why the great rivers of this region drain not only the southern slopes of the mountains but also their northern slopes, the watershed being much further north than the mean axis of the Great Himalayan range. It also explains the configuration and the enormous depths of their gorges, since the uplifting of the mountains and the erosion of the uplifted valleys occurred simultaneously.

Himalayan Rivers

2.17 The main Himalayan river systems are those of the Indus, the Ganga and the Brahmaputra.

The Indus System

The Indus which is one of the great rivers of the world, rises north of

Manasarowar in Tibet, and flows through Kashmir for a distance of 650 km. in a north-westerly direction as far as the peak Haramosh (7,397 metres). Thereafter, it turns sharply south through the Bunji gorge and then west, past Nanga Parbat into Pakistan. The tributaries of the Indus in the mountains are the Zaskar, the Dras, the Astor, the Shyok and the Shigar. In the plains, the main tributaries are the Jhelum, the Chenab, the Ravi, the Beas and the Sutlej.

The Jhelum flows through Kashmir from its source at Verinag, and crosses the Pirpanjal through a deep gorge. Before it crosses the borders of India into Pakistan, it receives the waters of the Liddar, the Sind and the Poonch rivers, which all rise in Kashmir.

The Chenab, formed by the streams of the Chandra and Bhaga which rise in Lahaul, crosses the Great Himalayan range, and after traversing Himachal Pradesh and Kashmir as the Chandra-Bhaga and the Chenab it enters Pakistan.

The Ravi, rising in Kulu, flows westward through a trough formed in the knot of mountains where the Pirpanjal and Dhaola Dhar ranges meet, and enters the Punjab plains near Madhopur. It enters Pakistan near Lahore.

The Beas rises near the Rohtang pass in Kulu, and flows through a precipitous gorge from Larji to Talwara before it enters the Punjab plains to join the Sutlej at Harike.

The Sutlej rises near the Darma pass on the Zaskar range, and flows through Tibet before entering India. It cuts through the Great Himalayan range and the outer Himalayas, and enters the plains at Rupar. After receiving the waters of the Beas at Harike, it flows past Ferozepore to form the boundary between India and Pakistan, entering Pakistan near Suleimanki.

The Ganga System

The Ganga is formed at Dev Prayag, where the Alaknanda and the Bhagirathi meet. It flows south and then south-east through the great plains to Farakka, which is the apex of the Ganga delta. In its long course through the foot-hills and plains, it gathers the waters of the Ramganga, the Yamuna, the Tons, the Gomati, the Ghaghara, the Son, the Gandak, the Burhi Gandak, the Baghmati, the Kosi and the Mahananda. The Ganga has a large number of spill channels running into the Bay of Bengal, which flow in a north-south direction. The most important of these are the Bhagirathi-Hooghly, the Jalangi, the Bhairab, the Mathabhanga and the Gorai. The Damodar which rises in the hills of Chhota Nagpur, flows into the Hooghly which is a branch of the Ganga.

Of the major rivers feeding the Ganga, the most important are the

Yamuna, which has its source very close to that of the Ganga, the Ghaghara, which rises in the Himalayas east of the Ganga and the Kosi which rises in the mountain of Nepal.

The Brahmaputra System

The Brahmaputra rises in Tibet where it is known as the Tsangpo. Where it emerges from the foothills in Arunachal it is known as the Siang and the Dihang, and it becomes the Brahmaputra after being joined by the Dibang and the Lohit rivers in its flow through the Assam valley.

The river has a smaller catchment than either the Ganga or the Indus, and gathers in its long course through Tibet, India and Bangladesh, the waters of the Raka Tsangpo, the Ngang Chu, the Kyi Chu, the Giamda Chu, the Dibang, the Lohit, the Subansiri, the Kameng, the Manas, the Tista, the Burhi Dihing, the Disang, the Kopili and the Dhansiri. After entering Bangladesh near Dhubri, it flows southward to join the Ganga at Goalundo. The Brahmaputra, in its course through the plains, divides into many channels and forms numerous braids which enclose islands, the largest of which, Majuli, is 1,250 sq. km. in area.

The Peninsular Rivers

2.18 The peninsular rivers fall into two categories, viz., the coastal rivers and the inland rivers. The coastal rivers are comparatively small streams. While only a handful of such rivers drain into the sea near the deltas of the east coast, there are as many as 600 on the west coast. The west coast rivers are of great importance. Although only 3 per cent of the areal extent of the basins of India is drained by these rivers, as much as 14 per cent of the country's water resources are contained in them. Their catchment areas experience very heavy rainfall which is carried swiftly down the steep rivers across the narrow coastal plains to the sea.

The inland rivers are of great antiquity, and their courses are stable and well-defined. Those flowing westwards, viz., the Narmada and the Tapi, between flanking mountain ranges, have narrow, elongated catchments, while the more numerous east-flowing rivers—the Mahanadi, the Brahmani, the Baitarani, the Subernarekha, the Godavari, the Krishna and the Cauvery—are wide, fan-shaped rivers with conspicuous deltas. They are less turbulent and capricious, and more predictable than the rivers of the Indus and the Ganga-Brahmaputra systems.

The Godavari

Of the east-flowing rivers of Peninsular India, the Godavari is the largest. It rises in the Nasik district of Maharashtra, and flows across the Deccan plateau into the Bay of Bengal. On its way through Maharashtra, Madhya Pradesh and Andhra Pradesh, it is joined by a large number of tributaries, viz., the Mula, the Pravara, the Manjra, the Purna, the Pranhita, the Indravati and the Sabari.

The Krishna

Second only in size and importance, is the Krishna which rises in the Western Ghats, just north of Mahabaleshwar. It flows from west to east through Maharashtra, Mysore and Andhra Pradesh before falling into the Bay of Bengal. Its main tributaries are the Koyna, the Bhima and the Tungabhadra.

The Mahanadi

One of the great rivers of India, the Mahanadi is 858 km. in length with a catchment of 132,090 sq. km. It rises near Sihawa in the Raipur district of Madhya Pradesh and flows northward for about 263 km. where it receives the first of its major tributaries, the Sheonath. It then runs eastwards gathering the Hasdeo, the Mand, the Ib and the Jonk. From Sambalpur it flows south and then east till it empties into the Bay of Bengal.

The Cauvery

The Cauvery, which is the fourth largest of the east-flowing rivers, is one river whose potential has been almost completely utilised. It rises near Mercara in Coorg district of Mysore at an elevation of 1,341 metres above sea level. It is joined in its course through Mysore and Tamil Nadu by a large number of rivers such as the Hemavati, the Lakshmantirtha, the Bhavani, etc. At Srirangam, it divides into two branches, the northern taking the name Coleroon which remains the main river, and the southern which retains the name of Cauvery. It is this southern branch which has been utilised as the main channel for the supply of irrigation water to crops in the delta.

POPULATION

2.19 Though India is the seventh largest country in the world in

terms of area, its population makes it the most heavily populated country in the world, next to China. The provisional estimate of population on the basis of the 1971 census is 547 millions.

When the First Irrigation Commission began its work in 1901, the population of pre-partition India, including Burma, stood at 238.4 millions. In the first thirty years after 1901, its population increased by only 41 millions. However, there was a tremendous explosion of population during the next forty years, i.e., from 1931 to 1971, largely because of a dramatic fall in the death rate. Between 1951 and 1961, the population of India increased by 78 millions. During the decade, the percentage growth of population was 21.63 against the population growth of only 5.41 per cent between 1901 and 1921.

The areas where the land-man ratio is lowest are the Ganga plains and the coastal areas, particularly Malabar, Konkan, south and north Tamil Nadu and the Orissa coast. Medium density areas include the plains to the south of the Ganga, the Deccan, Gujarat and Saurashtra; while the low density areas include the Rajasthan desert, the eastern and western Himalayas and the hills and plateaus of the country.

The northern plains and the coastal areas account for about one-third of the land-mass of India but they support about two-thirds of its population. Roughly, the northern plains with about 17 per cent of the total area, contain about 37 per cent of the population and the coastal areas with about 14 per cent of the land area, support about 25 per cent of the population. One-third of the population lives in the upland areas which cover one-half of the available land.

State-wise, the highest densities are in Kerala, West Bengal, Tamil Nadu, Uttar Pradesh and Bihar.

The all-India average density of population in 1971 was 182 persons per square km. The entire Gangetic Plain, excluding a few districts in Uttar Pradesh and Bihar, shows district densities of over 300 per square kilometre. The most densely populated area even in this heavily populated belt is concentrated in about eleven districts, comprising east Uttar Pradesh and west Bihar. In these districts, the density exceeds 450 (Varanasi 556, Gorakhpur 481, Deoria 521, Azamgarh 499, Jaunpur 496, Ballia 498, Ghazipur 459, Saran 620, Muzzafarpur 618, Darbhanga 605 and Patna 635).

There are also areas of high density in the Brahmaputra valley, and in some coastal districts like Trivandrum, Alleppey, Ernakulam, Cuttack, Hooghly and Howrah.

High density, good soil and good rainfall areas do not synchronise by sheer accident. It is precisely the last two factors which encourage concentrated settlement and high density of population. However, there is

not necessarily any direct relationship between density and actual rainfall, because areas in the Gangetic plain which get much less rain than Assam have population densities much higher than those in Assam. Rainfall beyond a certain degree does not confer any advantage, and can be a disadvantage. Areas with poor soils, or areas with low rainfall show low densities of population.

The influence of irrigation on population density is marked. For example, the Gang Canal System has turned a most infertile tract into a region of high fertility and high population density. Similarly, Tamil Nadu which gets only 813 mm. of rain, has much the same density as the best areas on the west coast with 2,794 mm. of rain, largely because of irrigation. Areas which are served by canals in western Uttar Pradesh, Punjab and Rajasthan, show much higher densities than areas with comparable soil in these States but without the benefit of irrigation.

From the point of view of agriculture a better index of population pressure would be the per capita availability of cultivable land per worker engaged in agriculture. The agricultural work-force being 126 millions, the availability of cultivable land per worker is only 1.44 hectares. The position varies from State to State. It is about 2 hectares or more in Gujarat, Haryana, West Bengal and Rajasthan, between 1.5 and 2 hectares in Madhya Pradesh, Maharashtra, Mysore, Orissa and Punjab and less than one hectare in Bihar, Kerala, Uttar Pradesh and Tamil Nadu.

CLIMATE

2.20 The presence of the great mountain mass formed by the Himalayas and its spurs, on the north, and of the ocean on the south, are the two major influences operating on the climate of India. The first poses an impenetrable barrier to the influence of cold winds from Central Asia, and gives the sub-continent the elements of the tropical type of climate. The second, which is the source of cool moisture-laden winds reaching India, gives it the elements of the oceanic type of climate. The shape and the distribution of major land forms introduce or accentuate modifications and variations of the two major climatic types mentioned above, and determine the precipitation of snow and rain.

India has a very great diversity and variety of climate, and an even greater variety of weather conditions. The climate ranges from continental to oceanic, from extremes of heat to extremes of cold, from extreme aridity and negligible rainfall to excessive humidity and torrential rainfall. It is necessary, therefore, to avoid any generalizations as to the prevalence of any particular kind of climate, not only over the country as a whole but over major areas in it. The variations in rainfall, tempera-

ture and humidity occasioned by the incursion of comparatively cool currents from the Indian Ocean across the Bay of Bengal and the Arabian Sea, and by the movement of shallow depressions which originate outside India, to the west, account for the extremely complex weather patterns which prevail over even those areas which can be grouped climatologically under a single type.

Subject to the considerations mentioned above, it is possible to demarcate five regions with, more or less, similar broad patterns of climate and weather :—

(i) North-west India comprising west Rajasthan, Punjab and Kashmir;
(ii) Central India which (for purposes of this categorization) includes east Rajasthan, Gujarat, the northern districts of Madhya Pradesh, Uttar Pradesh and Bihar;
(iii) The plateau region comprising the southern districts of Madhya Pradesh and the Deccan Plateau;
(iv) Eastern India comprising West Bengal, Orissa and Assam; and
(v) The peninsular coastal lands and plains.

Much of the behaviour of the weather and climate in India is the direct result of changes of pressure and the movement of currents from outside its borders into the country. These meteorological happenings outside its borders are related also to changes of pressure and temperature within the sub-continent itself.

Temperature

2.21 Temperature, rainfall and the amount of vapour in the air, are the major determinants of the character and growth of the principal crops.

The average thermal conditions in India are illustrated by the average range of temperature in different areas at different periods of the year.

The 3,200 km. of coast along the Arabian Sea and the Bay of Bengal, the Bay islands and the islands in the Arabian Sea are within the oceanic areas with a temperature range of 10–15°C. Beyond the coast are the sub-oceanic areas where the range is 15–20°C, the sub-continental areas where the range is between 20–25°C, and finally, the continental areas where the range is more than 25°C. Generally speaking, the temperature range is highest in the driest spring season and the lowest in the rainy season. During the winter season from November to February, due to the effect of continental winds over most of the country, the temperature decreases from south to north, and isotherms are almost latitudinally

parallel. The mean maximum temperature in the coldest months of this season, that is to say December and January, varies from 29°C in some parts of the Peninsula, to about 18°C in the north, while the mean minimum varies from about 24°C in the extreme south to below 5°C in the north. During the frequent cold waves which arise in the rear of some of the western disturbances, when cold winds from Turkestan enter India, the temperature sometimes falls by 8 to 10°C below normal.

From March to May is usually a period of continuous and rapid rise of temperature, and of a fall in barometric pressure in northern India. Simultaneously, there is a decrease of temperature in the southern Indian Ocean and in the adjacent land areas of Africa and Australia, and a rise in air pressure. As a result of these conditions, there is a steady transference northwards, both of the area of greatest heat and of the equatorial belt of low pressure. This northward transference of the area of greatest heat from March to May is illustrated below :—

Highest temperature	*Month*	*Area*
38°C	March	The Deccan Plateau.
38–48°C	April	Gujarat and M.P.
Over 48°C	May	North India

The highest temperatures occur in north India, particularly in the desert regions of the north-west where the maximum may exceed 48°C. The area of lowest air pressure also lies over north-west India, with a trough stretching from there to the Chhota Nagpur Plateau. Around this trough, a local circulation of air sets in during this period of rising temperature and of decreasing air pressure. This causes indrafts from the adjacent seas, of southerly winds across the West Bengal Coast, and north-westerly winds across the Bombay Coast. These cause violent local storms, particularly in West Bengal.

With the advent of the south-west monsoon, there is a rapid fall in the maximum temperature in the central portions of the country. Generally speaking, during the monsoon season, the temperature over the area covering the two-thirds of the country which gets good rain, is practically uniform.

In August, there is a marked fall in temperature, and when the monsoons retreat from north India in September, there is again a rise.

In north-west India, in the month of November, the mean maximum temperature is below 38°C and the mean minimum below 10°C. In the extreme north, temperatures drop below freezing point.

Precipitation and the hydrological cycle

2.22 The replenishment of the water resources of a country depends

on what we know as the hydrological cycle. Taking precipitation as the starting point of the cycle, it is clear that the total volume of precipitation is of major significance. However, precipitation can be greatly variable, not only in distribution but in extent and in timing, since it is dependent on meteorological and atmospheric conditions and also on the physical conditions which prevail on the land surface. Similarly, the succeeding elements of the cycle, namely, surface run-off and under-ground flow to the sea, are also subject to erratic and variable behaviour because of the many influences operating on them. Evaporation and transpiration play a vital part in the cycle and are affected by temperatures, wind velocities, surface vegetation and other highly variable factors.

A study of the flow of surface water necessitates the collection of a mass of data relating to river discharge stream flows; the status of watershed management, flood control measures, precipitation records, maps, and many other factors which have a bearing on the subject. Similarly, the movement of groundwater has also to be studied against the background of extensive data relating to hydrology, geology, soil chemistry, soil mechanics, forestry, drainage and the extent of soil erosion in the watershed. Finally, since differences in land forms and regional geology also have a decisive bearing on both the run-off and groundwater characterstics of any catchment area, precise and exhaustive data in these areas of information also have to be collected.

All elements of the hydrological cycle, precipitation, evaporation, stream-flow and the extent and nature of ground water, should be measured with the greatest possible degree of accuracy. Although precipitation records are fairly extensively maintained and are of high reliability, much remains to be done before the same degree of coverage and reliability can be claimed for records relating to the rest of the hydrological cycle in India, particularly in respect of evaporation.

Evaporation and evapo-transpiration

2.23 Evaporation in India closely follows the march of the seasons. When the winds are slight and temperatures low, evaporation is low. As temperatures rise and wind velocity increases, evaporation also increases. Evaporation rates reach their peak in the summer months of April and May, and the central areas of the country display the highest evaporation rates during this period. With the advent of the moisture-laden monsoon winds and heavy precipitation, there is a marked fall in evaporation rates.

Evapo-transpiration is controlled by two factors, namely, the availability of moisture at the earth's surface, and the ability of the atmosphere to supply energy to vaporise the water and to transport the vapour.

If the supply of water is unlimited, the loss of water in the form of evaporation and transpiration from an extensive cover of vegetation will depend on the atmospheric conditions. This loss is called potential evapo-transpiration (PE).

Normal monthly and annual values of about 300 stations in and near India have been computed and the isopleths of annual values, together with the highest and lowest mean monthly PE are drawn.

The annual PE ranges between 140 to 180 cm. over most parts of the country, and is highest over the extreme west Rajasthan in the Jaisalmer area. Parts of Mysore, Andhra Pradesh and Tamil Nadu show high values, exceeding 180 cm. PE is less than 140 cm. in (1) Coastal Mysore, (2) a narrow belt adjoining the Himalayan ranges running through Punjab to West Bengal, (3) parts of the Bihar plateau and east Uttar Pradesh, and (4) Assam.

Potential evapo-transpiration over the Peninsula increases from 10 cm. in December to 20 cm. in May. In the north-east, it varies from 5 cm. in December to 20 cm. in May. It rises to 28 cm. in June over west Rajasthan. After the onset of the monsoon, potential evapo-transpiration decreases generally all over the country due to the high humidity of the atmosphere, and the consequent suppression of evaporation from underlying water surfaces. In parts of Tamil Nadu, it continues to be high right up to the month of August. It is high during May over most parts of the country.

Rainfall

2.24 Rainfall in India is dependent, in differing degrees, on the south-west and north-east monsoons, on shallow cyclonic depressions and disturbances, and on violent local storms which form in regions where cool humid winds from the sea meet hot dry winds from the land, and occasionally reach cyclonic dimensions.

As most of the rainfall in the country is received during the south-west monsoon period, the pattern of annual rainfall resembles the pattern of that monsoon period. It generally exceeds 100 cm. in areas to the east of longitude 78°E. It extends to 250 cm. along almost the entire west coast and Western Ghats and over most of Assam and sub-Himalayan West Bengal. West of the isohyetal joining Porbandar to Delhi and thence to Ferozepur, rainfall diminishes rapidly from 50 cm. to less than 15 cm. in the extreme west. The Peninsula has an elongated area of less than 60 cm. with pockets of 50 cm.

Role of Orology : The orographical features which have been described earlier play a crucial role in influencing the climate of India, because they determine the flow of monsoon winds and the distribution and intensity of the rainfall.

The monsoon currents which enter India across the coast of deltaic Bengal, are deflected westwards up the plains of the Ganga because of the Himalaya and its north eastern spurs. As soon as the current comes under the influence of the Assam hills and the eastern ranges of the Himalayas it is forced to rise, and this rising movement causes heavy rainfall on the southern slopes of the Assam hills. The deflection of the monsoon currents westwards by the high barrier of the Himalayas causes rain on the lower southern slopes along the whole submontane region from Sikkim to Kashmir.

The Western Ghats and the Aravalli range play very much the same role in relation to the monsoon currents from the Arabian Sea. The former causes the currents to rise and there is heavy precipitation. There is moderate precipitation as the currents again rise to cross the barrier imposed by the Aravallis. Finally, the combined current of the Arabian Sea branch and the Bay of Bengal branch is forced up the southern slopes of the Himalayas leading to heavy precipitation.

The southern mountains of the Nilgiris and the Eastern Ghats play a major role in causing heavy precipitation when the south-west monsoon is retreating, and when cyclonic storms and depressions from the Bay of Bengal advance into the interior districts of south India.

However, it is not only during the south-west monsoon season that the Himalayas play a part in causing precipitation in northern India. In the winter (December-February), when shallow but extensive low pressure systems move across northern India from west to east, there is heavy precipitation in the form of snow, in the higher ranges of the Himalayan system, and moderate rain over the lower and outer ranges. The Himalayan snows and glaciers, which form the main storage for most of the Himalayan rivers, owe their replenishment to the heavy precipitation during this period of the year.

The effect of the orographical features of the land in rainfall distribution is clearly brought out by the annual as well as by the seasonal rainfall figures.

The Monsoons

2.25 The outstanding feature of the wind system over the Indian Ocean and the adjoining sea and land areas is the seasonal reversal of the monsoons in India.

During the late summer the winds blow from the south-west over the sea towards India and Burma in the currents of the south-west monsoon. This flow is completely reversed during the winter, in the north-east monsoon, when the flow of currents is from India and Burma over the Bay of Bengal and the Arabian Sea towards the Equator.

While the general trend of the currents during the two monsoons is south-west and north-east, respectively, various factors, such as the earth's rotation, the direction of the mountain ranges, the coastlines, etc., lead to a deflection in the direction of these winds so that the wind is not everywhere south-west in the south-west monsoon, nor everywhere north-east in the north-east monsoon. Only in the Bay of Bengal and in the western half of the Arabian Sea is the direction true to type.

The South-West Monsoon

2.26 Due to the rapid rise of temperature in May over the Asian mainland, there is a corresponding drop in air-pressure over the area. By the end of May the Asian high-pressure region is replaced by a deep low-pressure area which extends from Sudan in Africa through west Rajasthan to West Bengal. The air circulation in the Indian Ocean area and in the neighbouring seas becomes more and more vigorous, till, almost abruptly, the south-east trade winds from the south of the Equator extend north-west into the Bay of Bengal and the Arabian Sea. They are then caught up in the air circulation over India and deflected inland as the south-west monsoon.

Bursting on the Malabar coast in the first week of June, the monsoon establishes itself over most of the country by the end of the month. For agriculture, it is the months of June and July that are crucial, and the fate of the Kharif crop depends very largely on the distribution, and on the amount of rain which the monsoon brings to the land in these two months.

When the monsoon is fully established, the Arabian Sea current meets the Bay of Bengal current along the line of a low-pressure trough which normally extends from Orissa to north-west India. The depressions which have their origin in the Bay of Bengal move along this trough to strengthen the monsoon and to cause local precipitation. The trough is not stationary but moves inland along paths which are sometimes north and sometimes south of its normal position. This movement affects the distribution of rainfall.

The monsoon season is by no means one of continuous rain in any part of the country. There are alternations of heavy to moderate rain, and partial or general breaks when there is no rain. It is this pulsation of the monsoon which is of great meteorological and agricultural significance, and it is this feature which is of special concern to the planning of irrigation, where irrigation is intended to supplement monsoon rainfall for Kharif crops, or to enable rice-growers to tide over periods when, the crops are endangered because of breaks in the monsoon.

The strength of the monsoon current increases from June to July,

remains more or less steady in August, and begins to weaken in north India in September when there is a rapid decrease of rainfall towards the end of that month.

The Arabian Sea branch of the retreating monsoon passes over Rajasthan, Gujarat and the Deccan, while the Bay of Bengal current steadily retreats down the Ganga plain.

As the monsoon gradually weakens and withdraws from north-west India the monsoon trough of low-pressure also weakens and moves further south into the Bay of Bengal.

By the end of December the belt of low pressure usually passes out of the limits of the Bay of Bengal into the equatorial belt of the Indian Ocean. Similar conditions obtain at this time in the Arabian Sea.

The south-west monsoon season is responsible for 80 per cent or more of the total annual rainfall outside Assam, Bengal, coastal Orissa and the Peninsula south of latitude 18°N. excluding the West coast south of latitude 12°N. In Gujarat, Saurashtra, Kutch and adjoining Rajasthan and Madhya Pradesh, the season accounts for more than 90 per cent of the annual rainfall.

Orissa, east Madhya Pradesh, Bihar, West Bengal, Assam, the West Coast and Ghats and the sub-montane belt extending from north Bihar to Jammu, receive more than 100 cm. during this season. On the other hand, the Punjab, south of latitude 15°N. gets less than 50 cm. and in north-west India, the 50 cm. isohyetal line runs from Veraval in Saurashtra to Delhi and thence to Jammu. West of this line, the rainfall decreases rapidly to less than 10 cm. on the western edge of the boundary of Rajasthan. The lowest rainfall received in the country is in the extreme south-east Peninsula including the districts of Kanyakumari, Tirunelveli and adjoining areas, where it is less than 2.5 cm. In the rain shadow of the Western Ghats, rainfall is only 40 to 50 cm. during this season with patches where it is 30 cm. or less.

Hot Weather Rainfall—March to May

2.27 In the early part of the hot weather season western disturbances continue to enter India. These incursions bring rain to the north-west parts of the country. As they move eastwards, they manifest themselves in thunder-storms occasionally accompanied by hail-storms in the Ganga plains and the north-east. As the season advances, the thunder-storms become more and more frequent and the rainfall increases. In West Bengal and Assam, the intensity of thunder-storms is sometimes very great. In the interior, the hot-weather rainfall is slight and usually follows dust-storms. The hot-weather rainfall in West Bengal is of great importance for the early spring crop of rice, and in Assam for the valuable tea

crop. In the Khasi and Jaintia hills rainfall reaches 1000 mm.

In the south of the Peninsula, there are thunder-storms and rain in April and May but the distribution is irregular and the precipitation varies from 75 to 100 mm. In the north-west of the Peninsula, the season is characterised by hot winds with little or no rainfall, until thunder-storms, following shallow and temporary incursions of the monsoon winds, herald the advent of the monsoons.

The total rainfall in the period is less than 25 mm. in Rajasthan, Gujarat, Khandesh and Madhya Pradesh, between 50–140 mm. in the sub-montane districts in Uttar Pradesh, Punjab, Bihar, Rajasthan and Orissa; in excess of 250 mm. in Kerala, and over 500 mm. in Assam.

Cold Weather Rainfall

2.28 Precipitation during the cold weather is connected with shallow but extensive low-pressure systems or depressions which cut across north India from west to east, bringing snow to the high ranges and rain to the sub-montane tracts and the adjoining plains. Precipitation decreases from the sub-montane tracts southwards and eastwards, from Punjab to West Bengal. It again increases in West Bengal and Assam because moisture-bearing winds from the north Bay of Bengal are drawn into the fields of the depressions as they move eastwards. Rainfall is of the order of 50 mm. in Punjab and Assam, and veries between 18–25 mm. elsewhere in north India. Occasionally, these western disturbances also bring rain to the central parts of the country and the northern districts of the Peninsula. The significance of this light rain is out of all proportion to its intensity. It is upon this winter rain that the crop of wheat in the unirrigated areas depends in the north and central areas of the country. For Jammu & Kashmir this season accounts for 20 percent of the total annual rainfall.

Cyclonic Depressions

2.29 A considerable proportion of the monsoon rainfall over the greater part of India is associated with the movement of cyclonic depressions from the Bay of Bengal. As the typical depression moves towards the coast, there is rain in south and south-west Bengal and lower Assam. Then, as it moves slowly westwards it brings heavy rain to Madhya Pradesh, south Uttar Pradesh and the northern districts of the Peninsula. It may then extend into Rajasthan and Gujarat before merging with the seasonal low-pressure zone over north-west India. Sometimes, the depression moves north and breaks up in the sub-montane regions of Punjab or in Kashmir.

At each strengthening of the monsoon a depression forms at the head of the Bay of Bengal, and the cycle of rainfall begins again. On an average, 6–8 such cyclonic depressions of medium to severe intensity pass from the Bay of Bengal into the interior of the country between June and September.

The most favourable conditions for the development and growth of these cyclonic depressions are created in the region of transition between two different air masses, the "front" between land and sea air. This "front" is the result of the gradual withdrawal of the south-west monsoon and the gradual extension of the winds of the dry season from north India eastwards and southwards over the land and sea areas.

The North-East Monsoon

2.30 By the middle of October the belt of low pressure is transferred to the centre of the Bay of Bengal. Under its influence the retreating south-west monsoon current curves round as it is deflected towards the Peninsula from the north-east. This current is usually called the north-east monsoon.

The retreating monsoon winds cause occasional showers on the east coast, the amount of rainfall decreasing from the coast towards the interior. However, during October and November, cyclonic storms form in the Bay of Bengal and when they strike the Northern Circars or the Coromandel Coast they bring heavy rain to these areas.

The districts of the Deccan and Tamil Nadu receive rainfall in these months almost entirely because of these cyclonic storms or depressions, and hence the distribution of this rainfall is irregular, both in incidence and in duration. Before the end of December the north-east monsoon winds fully establish themselves over the whole region.

Variability of Rainfall

2.31 The picture would be incomplete, however, without a description of the variability of this rainfall—its unequal seasonal distribution, its still more unequal geographical distribution, and the frequent departures from the normal. It is not the actual amount of the deficiency and the interval between two occurrences but the period during which it occurs which is of critical importance. Even moderate deficiencies in the total rainfall can be disastrous during the critical periods of crop growth. It is the uncertainty born of these factors which makes agriculture precarious, and complicates planning for irrigation.

To facilitate the interpretation of normal rainfall, the co-efficients of

variation (CV) are calculated. The co-efficient of variation which is expressed as a percentage is defined by the formula :

$$\frac{\text{Standard deviation}}{\text{Normal}} \times 100$$

In the months of January-February of the winter season, the variability of rainfall is very high over the entire country, being 80 to 100 per cent, except in Kashmir and north-east Assam where it is 40 to 50 per cent. In March to May of the hot season, rainfall is highly variable over most of the country. Yet the CV is less than 30 per cent in north-eastern Assam and between 40 to 50 per cent over most of the Peninsula south of latitude 13°.

In June to September of the south-west monsoon season, the CV in July which is the rainiest month, is 40 to 50 per cent, except in Gujarat and Rajasthan and the Peninsula excluding the West Coast. Over a small area along the West Coast and in the extreme north-east Assam, it is less than 30 per cent. Over most of the Peninsula, east of the Western Ghats, it is as high as 80 to 100 per cent. Variability features for August are similar to those for July.

In September, the month of withdrawal of the south-west monsoon, CV shows a marked change in the Peninsula where it is only 60 per cent.

There is a marked change in the pattern in the monsoon months (June to September) compared to the pattern for individual months. In Assam and along the West Coast, CV is less than 20 per cent, with pockets of less than 15 per cent. The monthly variability in these areas is also not high. One may infer from this that in Assam and Bengal and to some extent in the central parts of the country rainfall is stable, with little likelihood of large variations from year to year. In east Rajasthan, Gujarat and the Peninsula, the seasonal variation is 30–40 per cent. The monthly variation is, however, quite large, indicating uncertainty of rainfall during different months in the monsoon season.

In the post-monsoon season CV is 50 per cent in Tamil Nadu, Kerala and the north-east portion of Assam. It is very high elsewhere. Even in Kashmir, which in this season gets up to 10 cm. of rainfall, the CV is more than 80 per cent. CV is 60 to 80 per cent in the central parts of the country and along the East Coast.

Despite the appearance of a large number of lines on the figure showing the CV of annual rainfall, it may be observed that in the entire country excluding Kashmir, Rajasthan and Gujarat, the CV generally varies between 15 to 30 per cent. Along the West Coast there is a small area around Mangalore where the CV is less than 15 per cent. The isoline of 20 per cent covers Bengal, the Bihar plateau, Orissa and Assam. Only

over Gujarat and Rajasthan does the CV exceed 40 per cent. The 20 per cent CV isoline runs along the West Coast south of Bombay and also covers almost the entire area of the country east of Longitude 80°. This shows that rainfall, though highly variable when considered according to months, is stable for the year as a whole.

The areas where rainfall is most uncertain are Gujarat, Rajasthan, Haryana and Punjab.

SOILS

2.32 The behaviour of soils under irrigation is of primary relevance. The capacity of the soil to take in water and hold it, and its effective rooting depths are important criteria for determining irrigability. The depth and frequency of irrigation is a function of soil properties. The greater the water-holding capacity, the greater will be the irrigation depth, and in consequence, the lower the irrigation frequency. If there is likely to be a drainage problem, then the main criterion is the hydraulic conductivity of the sub-soil or the sub-stratum. The ideal soil for irrigation is that which is level, or nearly level, with a deep rooting zone and favourable texture and moisture-holding capacity, and which is easily maintained in good tilth.

Indian soils, like most tropical soils, are generally deficient in organic matter and nitrogen. The phosphate deficiency is less marked and potash deficiency is rare.

The four major soil groups in India are (i) alluvial soils, (ii) black soils (regur), (iii) red soils, and (iv) laterite soils. Of less importance are forest soils, desert soils, saline and alkaline soils.

Alluvial Soils

2.33 These soils form by far the largest and most important of the soil groups in India, and cover nearly 15 million sq. km. in the most heavily populated areas of the country. The main features of these soils are derived from their having been deposited as silt by the rivers, particularly those of the Indo-Gangetic and the Brahmaputra systems. The silt comes from the weathering of the rocks in the mountains from which the rivers originate.

The older alluvium, known as "bhangar", is clayey, generally dark in colour, and full of "kankar". The newer alluvium, known as "khadar", is sandy, light in colour and with less "kankar".

In consistency, the soils range from drift sand to loams, and from fine silts to stiff clays.

In various parts of the country the texture of these soils, their reaction, and the amount of plant nutrients contained in them vary greatly. It depends on the nature of the parent material from which they have been formed, the elevation at which they are found, conditions of drainage, and whether they are old alluvium or new alluvium. Naturally, the productivity of these soils is also dependent on these variable factors. In the south, for example, the Godavari alluvium, which is black fertile mud, rich in lime, phosphates and potash, differs greatly from the Cauvery alluvium which is poor in plant nutrients. In Assam, the most prominent characteristic of the old alluvial soils is its acidity, whereas the new alluvium is often neutral or alkaline. In West Bengal, the old alluvium areas are much less fertile and productive than the new alluvium areas.

Occasional features of the alluvial soils are the presence of "hard-pans" at certain levels in the soil profile,caused by infiltrating silica or calcareous matter, and the presence of "kankar", particularly in the Indo-Gangetic alluvium of Uttar Pradesh, Punjab and Delhi. Occurrence of 'pans' impedes the penetration of plant roots and affects the percolation of water.

Generally speaking, alluvial soils are suitable for irrigation, and give a good response to the artificial watering of crops. Because of the abundance of sub-soil water and the softness of the strata to be penetrated, areas with alluvial soil are particularly well-adapted to irrigation by wells.

Black Soils (Regur)

2.34 The black soils have evolved from the weathering of the basalts in the Deccan and the Rajmahal trap, and from ferruginous gneisses and schists in Tamil Nadu. Known as 'regur' they cover an area of about 540,000 sq. km. in Maharashtra, the western part of Madhya Pradesh and parts of Tamil Nadu. These highly argillaceous, very fine-grained soils akin to the 'prairie soil' of the cotton growing areas of the U.S.A., contain a high proportion of calcium and organic matter, magnesium carbonates, considerable iron and fairly large quantities of magnesia, alumina and potash. In all black soil areas, and particularly in those where the soil is derived from ferruginous schists, there is generally a layer rich in nodules of "kankar", formed by the segregation of calcium carbonate at lower depths.

Irrespective of the nature of the parent rock from which black soils in India have developed, they do not differ much in general physical and chemical properties, provided they have developed under similar climatic conditions.

As a group, these soils are of fine texture and their clay content varies from 40–60 per cent. They are plastic and sticky when wet, and very

hard when dry. In deep black soils the presence of soluble salts in the sub-surface layers is usually the cause of deterioration in the structure of the soil. This creates difficulties in cultivation after the introduction of irrigation in such areas. The main problem of these soils is bad structure. Unless they are worked at the appropriate moisture level, their structure is spoilt and this adversely affects crop growth.

These soils have a high capacity for conserving soil moisture. They require the land to be well-prepared if it has to be good for irrigation. However, since these soils contain a fair amount of salts, they tend to become saline and alkaline as a result of uncontrolled irrigation. Care has to be taken to provide adequate drainage, not only to prevent salinisation but also to prevent saturation of the root zone of crops. It has been observed that the depth of the black soil under irrigated conditions is a significant factor in the selection of a suitable cropping pattern.

Contour bunding to conserve moisture in shallow and medium black soils has increased the yield of rabi crops, like jowar. Whenever these soils are shallow and overlie well-drained, open textured bed-rock, irrigation is possible. As they contract to a marked degree when drying, deep and fairly wide cracks appear, which impose limitations on the use of unlined field channels through these soils. When black soils formed from soda-lime felspars are subjected to heavy irrigation, they are likely to undergo changes due to continued hydration and decomposition, liberating lime and soda. In the absence of good leaching, this would develop salinity in the soil.

Black soils derived from the Deccan trap are thin, light-coloured and of poor quality on uplands and slopes, but deep, relatively clayey, and of good quality in the valleys. In some valleys, like those of the Godavari, the Krishna, the Narmada, and the Tapi, the soil is often as much as 6 m. deep. Outside the Deccan trap area in districts such as Surat and Broach in Gujarat, they can be 0.9-1.2 m. when shallow, or as much as 2.7 m. when deep.

The cotton-growing areas of Madhya Pradesh have deep heavy black soils; the soils of this group in Mysore are fairly heavy with a high concentration of salts, and are rich in lime and magnesium.

A transported basaltic type of alluvium, known as "Karail", is found in the lower Gangetic basin. This is brought down by the rivers which drain the trap-rock areas in the Bundelkhand region of Uttar Pradesh.

Red Soils

2.35 Formed by the weathering of igneous and metamorphic rocks, comprising gneisses and schists, red soils occupy an area of about 350,000 sq. km. in Tamil Nadu, Mysore, south-east Maharashtra, east Andhra

Pradesh, Madhya Pradesh, Orissa and Chhota Nagpur. They also occur in the Santhal Parganas in Bihar, in West Bengal and in the Mirzapur, Jhansi and Hamirpur districts of Uttar Pradesh.

Red soils are generally poor in lime, potash and iron oxide, and low in phosphorous. In Tamil Nadu, where they predominate, they are deficient in organic matter and poor in plant nutrients. In the plantation districts of Shimoga, Hassan and Kadur in Mysore State, where they are loamy, they are rich in total and available potash, reasonably rich in total phosphates, but low in nitrogen. In Bihar, they are red and acidic with sufficient potash but insufficient phosphate. In Andhra Pradesh a type of red soil, locally known as 'dubba' soil, is loamy sand to very coarse sandy loam, pale to brown in colour, with reddish-brown patches. It is invariably neutral in reaction and low in soluble salts with almost negligible organic matter, severely eroded and very often covered with gravels of various sizes. The red soils have little moisture-retaining capacity. On account of their permeability and low moisture-retaining capacity, these soils react well to the application of irrigation water, are friable, well-drained and easily managed.

Laterite Soils

2.36 Laterite soils which are peculiar to India and to some other tropical countries with an intermittently moist climate, are essentially composed of a mixture of the hydrated oxides of aluminium and iron with small quantities of manganese oxide, titania, etc. They cover about 248,000 sq. km. Laterites may be carried to lower levels by streams, and where they are redeposited, they again form into a compact mass. Thus, there are high-level laterites resting on rock, and low-level laterites which are detrital deposits. They are usually well-developed on the summits of hills in the Deccan, Mysore, Kerala, Madhya Pradesh, the Eastern Ghat region, Orissa, Maharashtra, Malabar, and in parts of Assam. They have conspicuously good drainage capacity.

Laterite soils are very poor in lime and magnesium, and deficient in nitrogen. Occasionally, phosphates in the form of iron phosphate may be high, but potash is deficient. Occasionally, the humus content is high. Generally, these soils are poor in available phosphorous and calcium. They have a relatively low organic matter content, low clay activity, a low content of primary minerals and an accumulation of sesquioxides and leaching of silica.

The high level and low level laterites of Tamil Nadu are rich in plant nutrients, supporting paddy in the low levels, and tea, cinchona, rubber and coffee at the higher levels. The higher the level, the more acidic the soil. Plantation crops, like tea, rubber, cinchona, coconut and arecanut,

are also grown in laterite soils of the West Coast.

In Bihar and Orissa, laterites are found as caprock on hills and plateaus, and also in some valleys where the deposits are of fair thickness. In Orissa, laterite murrum and laterite rock are sometimes found together.

Forest Soils

2.37 Forest soils which cover an area of 285,000 sq. km. are formed by the deposition of organic matter derived from forest growth. Broadly, they are of two kinds, (1) those which are formed under acidic conditions with a low base status, where the humus is acid, and (2) those formed under slightly acidic or under neutral conditions with a high base status which favours the formation of brown earths.

Desert Soils

2.38 These cover an area of about 142,000 sq. km. in the arid and semi-arid regions of Rajasthan and south Punjab. Soil growth is inhibited in the area by a mantle of sand blown from the coastal regions and the Indus valley, and by sand formed by the disintegration of rocks in desert conditions of geologically recent origin. Some of these soils contain high percentage of soluble salts, are alkaline and poor in organic matter. They are reclaimable with the appropriate type of irrigation.

Saline and Alkaline Soils

2.39 By reason of inadequate drainage in many parts of the great alluvial plains, there is a heavy concentration of salts, which manifests itself during the summer months, particularly, in a white efflorescent crust on the surface of the soil. It has been estimated that about 1.25 million hectares of land in Uttar Pradesh, and about 1.21 million hectares of land in the Punjab have been thus affected. More than 173,000 sq. km. in Gujarat comprising the estuaries of the Narmada, the Tapi, the Mahi and the Sabarmati have also been affected, as well as portions of Dharwar and Bijapur.

The reclamation of these soils is a protracted and expensive process. Heavy irrigation can remove water soluble salts from the soil surface, and continuous flooding over a period can reclaim the saline soil, but this method is feasible only if there is natural drainage, a large supply of irrigation water of good quality and a low water table.

Peaty and Marshy Soils

2.40 Peaty saline soils (kari) are heavy black soils, highly acidic

and rich in organic matter. The peaty soils have a high content of organic matter and thus they are suitable for top dressing of bad soils. These soils have an accumulation of large amounts of water-soluble alkaline salts.

Marshy soils are found in the coastal tracts of Orissa, the Sunderbans and other areas of West Bengal, north Bihar, the Almora district of Uttar Pradesh, and the south-east coast of Tamil Nadu. They are the result of water-logging, anaerobic conditions of the soils, and the presence of iron and varying amounts of organic matter. These conditions are typical of depressions formed by basins of dried-up rivers and lakes in the alluvial and coastal areas.

CHAPTER III

LAND AND WATER RESOURCES

Land Resources

The total geographical area of the country is 328 million hectares. Of this only 305.5 million hectares are accounted for in the latest available land use statistics (1967–68). The difference of 22.5 million hectares, for which land use statistics are not available, largely consists of mountains, deserts and forests in inaccessible areas.

3.2 The table below shows the classification of land use for the years 1950–51, 1955–56, 1960–61 and 1967–68.

Table 3.1
Land Utilisation Statistics

(Thousand hectares)

Classification	1950–51	1955–56	1960–61 (R)	1967–68*
1	2	3	4	5
Area under forest	40,482	51,343	54,052	62,323
Area not available for cultivation	47,517	48,396	50,751	48,087
(i) Land put to non-agricultural uses	9,358	13,920	14,840	15,588
(ii) Barren and unculturable land	38,159	34,476	35,911	32,499
Other uncultivated land excluding fallow land	49,446	38,895	37,637	34,561
(i) Permanent pastures and other grazing land	6,675	11,473	13,966	13,881
(ii) Land under misc. tree crops and groves not included in net sown area	19,828	5,885	4,459	4,068
(iii) Culturable waste	22,943	21,537	19,212	16,612
Fallow land :	28,124	24,127	22,819	20,833
(i) Fallow land other than current fallows	17,445	12,544	11,180	8,775
(ii) Current fallows	10,679	11,583	11,639	12,058

Table 3.1—Contd.
Land Utilisation Statistics

(Thousand hectares)

Classification	1950–51	1955–56	1960–61 (R)	1967–68*
1	2	3	4	5
Net area sown	118,746	129,156	133,199	139,702
Total reporting area**	284,315	291,917	298,458	305,506
Area for which no return exists	43,773	36,131	29,590	22,542
Total geographical area***	328,048	328,048	328,048	328,048

*Provisional.
(R) Revised.
**Due to change in coverage, the figures are not comparable from year to year.
***According to the Surveyor General of India.

3.3 In interpreting the data in the table, a good deal of caution would be needed as the value of much of the statistical matter is vitiated by the lack of uniformity in coverage which has led to overlapping.

3.4 Under the category 'land not available for cultivation' are included barren, unculturable land, and land which has been put to non-agricultural use. Similarly, culturable waste, permanent pastures and other grazing land, as well as land under miscellaneous tree crops and groves, have been lumped together in the category 'other uncultivated land including fallow land'.

3.5 Subject to the reservations mentioned above, the major trends in land use are, (i) an increase in the reporting area from 284.3 million hectares to 305.5 million hectares; (ii) an increase of 21.8 million hectares in the land under forests; (iii) a decrease of about 7.2 million hectares in fallow land including current fallows; and (iv) a reduction of about 15.7 million hectares in the area under miscellaneous tree crops and groves.

There has been no appreciable increase since 1955–56 in the net area sown.

3.6 Considering the tremendous increase in population and the growing pressure on land, this fact indicates, perhaps, that the upper limit in respect of new land capable of being brought under the plough is being approached.

3.7 The State-wise distribution of the geographical area, cultivated and irrigated areas during 1967–68 are as below :

Table 3.2
Land Utilisation Statistics—States

(Thousand hectares)

State	Total Geographi- area	Net area sown	Total cropped area	Net irrigated area	Gross irrigated area
1	2	3	4	5	6
Andhra Pradesh	27,675	11,367	12,794	3,089	3,972
Assam	9,962	2,393	2,907	612†	612†
Bihar	17,388	8,284	10,895	2,011	2,461
Gujarat	19,598	9,802	10,420	1,108	1,166
Haryana	4,422	3,514	5,150	1,132	1,780
Himachal Pradesh	5,567	547	899	90	151
Jammu & Kashmir*	22,224	675	808	278	301
Kerala	3,886	2,129	2,758	411	572
Madhya Pradesh	44,284	17,797	19,653	1,143	1,162
Maharashtra	30,776	18,267	19,197	1,476	1,481
Mysore	19,177	9,987	10,417	1,082	1,219
Nagaland	1,653	47	49	12**	12**
Orissa @	15,584	5,989	7,446	977£	1,141£
Punjab	5,036	3,992	5,441	2,333	3,464
Rajasthan	34,221	15,097	16,657	1,865	2,141
Tamil Nadu	13,007	6,083	7,309	2,629	3,476
Uttar Pradesh	29,441	17,467	22,709	5,657	6,352
West Bengal @	8,785	5,569	6,653	1,478	1,499
Union Territories	15,360	696	864	140	170
All India	328,048	139,702	163,026	27,523	33,132

*Relates to the year 1965–66.
@ Relates to the year 1964–65.
† Relates to the year 1953–54.
**Relates to the year 1956–57.
£Relates to the year 1955–56.

Water Resources

3.8 The Commission has been asked to prepare a broad outline for the development of irrigation of all types. This calls for a study of the country's water resources, their occurrence, present use and future possibilities.

3.9 The principal water resources are :

(1) Surface resources through rivers and streams; and
(2) Ground water.

Surface Water Resources

3.10 An adequate, accurate and long range study of the flows in rivers is essential. Lack of data leads to delays in the implementation of projects and sometimes to under-designing or waste.

3.11 The Irrigation Commission of 1901–03 had remarked that the data required to ascertain the extent to which rain water was utilised for irrigation was in many respects incomplete. While records in respect of rainfall were available, data in respect of river flows was not available even for many of the most important river basins. The Commission had, therefore, to rely upon an assessment based on co-efficients of run-off and actual flow which it described as "mere approximations". It estimated the annual flow of all the river systems in India (as it was then, but excluding Burma, Assam and East Bengal) as 1,443,172 million cubic metres (51 billion c.ft. or 1170 million acre feet) of water.

3.12 It was only in 1945–46, when the Central Water & Power Commission (CW&PC) was set up, that further thought was given to the assessment of the country's water resources as a whole. Dr. A.N. Khosla, who was the Chairman of the CW&PC from 1945 to 1953, developed a formula in the 1940s, based on his studies of the Sutlej, the Mahanadi and other river systems.

3.13 The Khosla formula, as it was popularly known, describes run-off as a function of rainfall and temperature. The run-off is the residue of rainfall after the deduction of losses. The losses arise on account of evaporation and transpiration which in turn are functions of the temperature of the area. The formula reads as follows :

$$R_m = P_m - L_m \qquad \cdots (1)$$

$$L_m = \frac{T_m - 32}{9.5} \qquad \cdots (2)$$

Where R_m = monthly run-off
P_m = monthly rainfall
L_m = monthly evaporation loss
T_m = mean monthly temperature

The annual run-off is a sum total of the monthly run-off.

3.14 Based on a study of a number of river systems, Dr. Khosla also worked out a formula for determining the annual run-off on a

yearly basis for areas where monthly rainfall and temperature data were not available. This formula reads as follows :

$$R_A = P_A - XT_A$$

Where R_A = annual run-off
P_A = annual rainfall
T_A = mean annual temperature
X = constant for a given catchment

3.15 According to the studies made by Dr. Khosla, the total annual flow of all the river systems in India comes to 1,672,599 m.cu.m. (1,356 million acre feet) as detailed below :

Table 3.3*
Surface Water Resources

Region	Catch-ment area (square miles)	Annual Normal rainfall (inches)	Annual Mean tempera-ture (°F)	Annual Loss (inches)	Annual Run-off (inches)	Annual Run-off (million acre feet)
1	2	3	4	5	6	7
Rivers falling into Arabian Sea (excluding the Indus System)	189,790	47.95	77.9	23.11	24.84	251.46
Indus Basin in India	136,673	21.86	54.7	13.02	8.84	64.43
Rivers falling into Bay of Bengal, other than Ganga and Brahmaputra systems	467,309	42.77	79.0	29.37	13.40	334.03
Ganga system	376,818	43.76	62.2	24.00	19.76	397.09
Brahmaputra System	195,460	48.11	46.8	18.47	29.64	308.95
Rajputana	64,887	11.48	79.1	11.48	—	—
Total :	1,430,937	41.03	—	23.26	17.77	1,355.96

Say 1,672,599 in m.cu.m (1,356 million acre feet).

*An appraisal of water resources by Shri A. N. Khosla—UNESCO.

3.16 The CW&PC also worked out the surface water resources of different regions during the period 1954–66. This study was based largely on statistical analysis of the flow data wherever it was available and on suitable rainfall run-off relationships wherever observed data was meagre. According to this study in the year 1960 the water resources of the various basins amounted to 1,881,057 m.cu.m. (1,525 million acre feet) as detailed below.

Table 3.4
Surface Water Potential

River Basin	Water potential (million acre feet)	Remarks
1	2	3
Zone No. I — West Flowing Rivers		
1. River basins of Kerala	30.03	
2. River basins of Madras and Bombay below Tapi	146.62	
3. Tapi basin	16.00	
4. Narmada basin	32.50	
5. Basin above Narmada	22.50	
Total :	247.65	
Zone No. II—East Flowing Rivers		
6. Tambraparni and Vaigai river basins	7.08	
7. Cauvery basin	15.08	
8. Mahanadi and other basins between Ganga and Godavari	106.52	
9. Godavari basin	93.52	
10. Krishna basin	46.83	
11. Pennar	5.56	
12. Basins between Cauvery and Pennar	13.70	
Total :	288.29	
Zone No. III		
Indus basin	64.43*	*Figure as estimated by Khosla's formula.
Zone No. IV—Ganga basin		
13. Chambal river basin	19.71	
14. Jamuna river basin	53.20	
15. Ram ganga basin	15.10	
16. Tons river basin	5.09	
17. Gomti basin	6.86	
18. Sone and other basins between Tons and Sone	40.65	
19. Gogra	92.65	
20. Right bank tributaries below Sone	36.60	
21. Left bank tribuaries below Gogra	141.60	
22. Main Ganga	34.50	
Total :	446.00	
Zone No. V		
23. Brahmaputra and Barak basin	478.90	
Grand Total for Zone Nos. I, II, IV and V	1,525.27	

3.17 In 1961 the Planning Commission constituted a Committee on Natural Resources. This Committee set up a 'Technical Committee on Water' to review the studies made so far and to recommend steps that would lead to a more accurate assessment.

As a result of its recommendations the task of assessment was assigned to various agencies in the Ministry of Irrigation & Power. Several studies have been undertaken by the Surface Water Resources Directorate (SWRD) of the CW&PC and some of its provisional findings have been made available to us.

3.18 The estimates made by Dr. Khosla in 1949, the CW&PC in 1950 and the SWR Directorate do not tally. There is a wide margin of difference. This clearly underscores the importance of scientific observations for each river system.

3.19 Most of the gauge and discharge observations made so far have been undertaken in connection with existing or proposed projects. There was no attempt, until a few years ago, to make gauge and discharge observations aim at a study of the water resources of a river system as a whole.

3.20 At present observations are recorded by various agencies—State Irrigation/Public Works Departments in connection with irrigation, hydro-electric projects; Highways Departments in connection with designs of bridges, Railways for their requirements; Public Health Departments in connection with development of water supply schemes. The Union Government has also recently undertaken gauge and discharge observations on the Krishna and the Godavari rivers following the recommendations of the Krishna-Godavari Commission in 1962. The CW&PC has also been entrusted with the task of measuring discharges at key stations on a number of other river systems.

3.21 In 1958, the Ministry of Irrigation & Power set up a number of gauge and discharge observation stations on the Ganga and its tributaries to assess the flow according to accurate international standards.

3.22 The following Union Government organisations undertake hydrologic observations and the collection, compilation and study of data :

(1) Indus Water Organisation.
(2) Ganga Basin Organisation—Ganga Basin Water Resources Circle.
(Both directly under the Ministry of Irrigation & Power).

(3) Central Gauging Circle.
(4) Central Discharge Circle.
(5) Chenab Investigation Division of Chenab Investigation Circle.
(6) Surface Water Resources Directorate.
(7) Directorate of Statistics.
(All directly under the control of Central Water & Power Commission).

3.23 The Indus Waters Organisation does not directly undertake hydrologic observations in the basin but collects and compiles data received from the concerned State Governments and conducts studies of the surface water potential of the Indus Basin in Indian territory.

3.24 The Ganga Basin Water Resources Circle under the Ganga Basin Organisation, which has been in existence for the last twelve years, conducts systematic hydrologic observations at a number of key stations in the basin and undertakes studies connected with the assessment of the surface water potential of the Ganga system. This Circle has six water resources survey divisions with eighteen sub-divisions.

3.25 The Central Gauging Circle of the CW&PC was set up in 1963 as a sequel to the recommendations of the Krishna-Godavari Commission, to conduct systematic hydrologic observations at a number of key stations in the Krishna-Godavari basins. It has three divisions and twelve sub-divisions.

3.26 Gauges and discharges at 30 sites in the Krishna basin and at 34 sites in the Godavari basin are recorded by this circle. In addition, gauges and discharges at 8 sites in the Krishna basin and at 4 sites in the Godavari basin are recorded by the concerned State Governments.

3.27 The Central Discharge Circle in the CW&PC was set up recently to conduct systematic hydrologic observations in the river basins of Narmada, Mahanadi, Brahmaputra, Baitarani, Subernarekha, Barak, Imphal, Sabarmati, streams in Saurashtra, streams between Penner and Krishna, Tapi, Palar, Cauvery, Penner, Vaigai, Luni and other west-flowing rivers. It has 3 divisions and 9 sub-divisions. This Circle will conduct gauge and discharge observations at 65 stations out of which 47 stations will be new, in addition to the 18 existing ones.

3.28 One Division (the Chenab Investigation Division with headquarters at Jammu) with three sub-divisions under the Chenab Investigation Circle is engaged in making systematic hydro-meteorological

observations in the Chenab basin. Gauges and discharges are being observed at twelve sites in the basin.

3.29 Quite a few rivers are still without proper gauging stations. Automatic water-level recorders for determining the peak as well as the shape of the flood hydrographs, are not in use in a number of major river basins.

3.30 Another disturbing feature brought to our attention is the lack of continuity. Gauge and discharge sites are operated spasmodically. Gauge and discharge observations set up in connection with particular projects are often closed merely because there happens to be delay in the implementation of the projects concerned. Lack of continuity is a great handicap in hydrologic assessment and analysis.

3.31 It is only when continuous and long range measurements of river flows are available that it is possible to plan for the development of water resources in the most efficient and economical manner.

3.32 The Commission has carefully considered problems connected with the assessment of water resources. The nation's water resources are immense and their assessment should be a fundamental task. The Commission, therefore, recommends that the Union Government should undertake the observation of gauges and discharges at all key points, on all the major river systems and their principal tributaries.

Ground Water Resources

3.33 A scientific assessment of the ground water potential of the country was not undertaken until a few years ago. Wells used to be constructed, and are even now being constructed, on the basis of local expertise and on the advice of water diviners. The construction of tubewells in the Ganga alluvium of Uttar Pradesh was taken up in the 30's but this was based on local knowledge and not on any assessment of the groundwater potential. Groundwater mapping and groundwater exploration were, until recently, sporadic and limited to specific areas.

3.34 It was not till 1936 that a large scale programme for the construction of tubewells was undertaken in the Ganga alluvium of Uttar Pradesh. 1,500 tubewells were constructed and channels were laid to irrigate 3,367,000 hectares.

3.35 With the onset of the Second World War there was a setback to groundwater exploration and it was only after Independence that serious attention was again paid to groundwater investigation. In the early 50's the United States of America offered to assist the Union Government to instal a large number of tubewells. As part of this programme and also to explore further groundwater sources, systematic investigations were initiated.

The Geological Survey of India (GSI) was responsible for systematic investigation and mapping of groundwater in the country as a whole. The investigations included geo-physical and geo-chemical studies, together with a certain amount of preliminary drilling necessary for the assessment of potential aquifers.

3.36 In 1954, the Exploratory Tubewells Organisation (ETO) was set up in the Ministry of Food & Agriculture (Department of Agriculture) at the Centre. The main function of this Organisation, at that time, was to carry out detailed exploration and development, including quantitative and qualitative assessment of groundwater aquifers in areas already mapped by the GSI.

3.37 The ETO has done extensive work in Rajasthan, the foothills of the Himalayas, the coastal alluvial tracts of Orissa, Andhra Pradesh and Tamil Nadu, and the Narmada, Tapi and Purna valleys. It has also done some exploration in and around Dehradun and eastern Rajasthan. In all, it has covered a total area of about 181,300 sq. km. Of this, 62,160 sq. km. have been proved groundwater worthy for future development. The performance of this Organisation is summarised below :

(1) No. of wells drilled	1,646
(2) No. of successful wells	1,140
(3) No. of wells abandoned	506
(4) Percentage of success	About 70
(5) Total length drilled	About 274,320 m.
(6) Total area explored	About 181,300 sq. km.
(7) Proven area for groundwater development.	About 62,160 sq. km.
(8) Potential created for additional tubewells (in number).	About 12,000
(9) Total area likely to be benefited by tubewell irrigation (approx.)	About 0.97 million hectares.
(10) Total expenditure gross on groundwater exploration project	

(1) 1st and 2nd Plans	Rs. 41.2 million.
(2) Third Plan	Rs. 34.0 million.
(3) 1966–69 (anticipated)	Rs. 34.0 million.

3.38 With the increased emphasis on groundwater development in the last few years, the activities of the ETO have been intensified. The ETO has been preparing feasibility reports for compact area schemes to be financed through various lending institutions. It has been assisting and guiding States to set up their own Groundwater Investigation Cells under centrally sponsored programmes. It has also been carrying out a programme for training State technical personnel.

3.39 Since the ETO's programme was mainly confined to deep exploration, the Department of Agriculture initiated in 1966–67 a centrally sponsored groundwater survey and investigation programme. Under this, State Governments were helped to undertake investigations which would promote groundwater development including dug-wells, boring and deepening of tubewells and shallow tubewells. Detailed guidelines were furnished to the State Governments, and we are glad to note that the following States took advantage of this programme and set up their own Groundwater Units :

Andhra Pradesh
Bihar
Gujarat
Kerala
Maharashtra
Mysore
Orissa
Rajasthan
Tamil Nadu

We hope that the other States which have not yet initiated action under this programme will do so at a very early date.

3.40 Surface and groundwater resources are interlinked. Therefore, integrated studies are needed to cover both the resources. So far, the work of the Central Ground Water Board (CGWB) has been confined mainly to the alluvial and semi-consolidated areas, whereas 70 per cent of the total geographical area of the country is covered by hard rock. The CGWB should equip itself to undertake exploratory programmes in the hard rock areas. Even in areas already explored there is need for deeper exploration to evaluate fully the available groundwater potential. We have been informed that under the programme "Operation Hard Rock" for the exploration of non-ferrous metals whatever data is obtained

on groundwater is passed on to the ETO and GSI for further use. The ETO has undertaken a special project for groundwater assessment in Rajasthan with the assistance of UNDP. We understand that more such studies are to be undertaken in the near future.

3.41 Investigations in hard rock areas will go a long way towards overcoming some of the problems of the chronically drought affected districts.

3.42 The GSI has been carrying out regional geo-hydrological studies of the occurrence, form and slope of the water table in the country in relation to different geological conditions. The field studies carried out by it area-wise are :—

(i) *Alluvial tracts/River basins or Valleys*
Himalayan valleys like the Kashmir and Dun valleys, Indo-Ganga alluvial tract, Brahmaputra valley, Narmada, Tapi, Purna and adjoining alluvial tracts, Gujarat alluvial tract, Chambal Valley in Madhya Pradesh, Luni river basin in Rajasthan, Cooum basin, Mayuram alluvial tract, Kortallaiyar and Araniar basins in Tamil Nadu.

(ii) *Areas underlain by semi-consolidated rocks*
Zalawad and Kutch districts of Gujarat, Jaisalmer, Barmer and Sikar districts of Rajasthan, Midnapur district of West Bengal, East Godavari, West Godavari and Krishna districts of Andhra Pradesh, Cuddalore district of Tamil Nadu.

(iii) *Areas covered by wind-blown sands*
Barmer, Jaisalmer, Bikaner, Churu, Sikar and Jodhpur districts of Rajasthan.

(iv) *Consolidated or hard rock areas*
Udaipur, Chittorgarh, Bhilwara and Ajmer districts of Rajasthan, Jhansi, Banda, Hamirpur and Mirzapur districts of Uttar Pradesh, Hazaribagh district of Bihar, Bastar district of Madhya Pradesh, some portions of Maharashtra, Gujarat, Mysore, Madhya Pradesh and Andhra Pradesh occupied by Deccan traps, North Arcot, Tirunelveli, Coimbatore and Salem districts of Tamil Nadu, Chitradurga, Mysore and South Kanara districts of Mysore, Palghat district of Kerala.

(v) *Coastal tracts*
In Gujarat, Kerala, Tamil Nadu, Andhra Pradesh, Orissa, West Bengal, Andaman and Nicobar Islands.

(vi) *Sub-montane valleys*
Parts of Rajasthan and Uttar Pradesh.

(vii) *Waterlogged areas*

Ferozepur, Hoshiarpur, Karnal, Rohtak and Ambala districts of Punjab and Haryana, New Delhi area, Tarai region and Jalaun district of Uttar Pradesh, Bhind, Gwalior and Morena districts of Madhya Pradesh.

(viii) *Large industrial and mining enterprises*

Greater Calcutta area, Neyveli lignite field, Khetri copper project, proposed fertilizer project in Pondicherry.

(ix) *Saline tracts*

In Punjab, Rajasthan, Uttar Pradesh, Madhya Pradesh, Orissa, Mysore and Tamil Nadu.

(x) *Thermal springs*

In Bihar, Maharashtra, Assam, Sikkim, West Bengal, Orissa, Madhya Pradesh, Punjab, Haryana and South India.

(xi) The areas covered in the various States by the geo-hydrological studies conducted by the GSI are as follows :

State	*Area covered* sq. km.
Andhra Pradesh	46,900
Assam & Meghalaya	17,000
Bihar	36,900
Gujarat	46,945
Haryana	33,979
Jammu & Kashmir	5,658
Kerala	7,690
Madhya Pradesh Maharashtra	44,135
Mysore	31,730
Orissa	38,700
Punjab	25,510
Rajasthan	175,888
Tamil Nadu	21,345
Uttar Pradesh	142,971
West Bengal	52,300
Chandigarh	112
Delhi	1,484
Himachal Pradesh	2,200
Manipur	1,200
Tripura	3,000
Total	735,647

3.43 The studies have indicated many promising areas for groundwater development in Punjab, Haryana, Uttar Pradesh, Bihar, West Bengal and Assam and the 'bhabar' and 'tarai' areas. In Jaunpur, Faizabad and Ghazipur districts of Uttar Pradesh, promising aquifers have been located below a depth of 180 metres. Large sources of groundwater have also been located in the northern part of the Greater Calcutta area.

3.44 Considerable reserves of groundwater of suitable quality have been found in the thick alluvial deposits of the Narmada valley near Hoshangabad.

A narrow belt in the northern part of the Purna valley (Tapi basin) alluvium has also been found to have a limited groundwater potential.

The GSI has also located considerable reserves of fresh groundwater in the heart of the Great Indian Desert near Jaisalmer, and near Khetri in Rajasthan.

The Rajahmundry and Tirupati sand-stones in Andhra Pradesh and the Cuddalore sand stones in Tamil Nadu have been proved to be good water-yielding formations. The Neyveli lignite field is another good store-house.

Estimates of available resources

3.45 Although groundwater has been located at a number of places, no systematic quantitative assessment has so far been made. Such an assessment can be made only on the basis of complete data on sub-surface geology, rainfall, evapo-transpiration, run-off, percolation zone and extent of saturation, hydraulic gradient, aquifer characteristics, geo-chemistry of water, etc. The collection, compilation and analysis of such data will take time. The regime of groundwater in various regions has yet to be systematically studied over a number of years. However, a very rough assessment of groundwater resources has been attempted by Dr. K. V. Raghava Rao and his colleague of the CGWB.

The occurrence of ground water, according to their assessment, is indicated in Table 3.5.

3.46 In order to plan for the optimum utilisation of groundwater resources the following studies are urgently needed :

(1) Assessment of groundwater resources separately for each river basin, on the basis of data currently available;
(2) Additional measures necessary for a comprehensive and dependable assessment of the ground water resources in each river basin and sub-basin;

Table 3.5*
Ground Water Resources

State	Amount of Contribution of rainfall to ground-water-re-charge	Possible recharge due to canal infiltration	Total	Evapo-transpira-tion and sub-surface run-off losses	Net ground-water-re-charge	Annual draft by the end of 1967–68	Net ground-water-re-charge available for further groundwater development	Area irri-** gated by groundwater at present (million acres)
1	2	3	4	5	6		8	9
Andhra Pradesh	20.0	4.6	24.6	30	17.2	3.57	13.6	1.4
Assam Region (including Nagaland. NEFA etc.)	40.7	1.2	41.9	60	16.7	0.003	16.7	—
Bihar	26.9	4.4	31.3	30	21.9	2.35	19.5	1.2
Delhi	0.5	—	0.5	30	0.3	n. a.	—	—
Gujarat	14.1	0.4	14.5	30	10.2	4.13	6.1	1.75
Haryana	3.0	1.6	4.6	25	3.5	0.75	2.7	0.75
Himachal Pradesh	2.3	—	2.3	60	0.9	n. a.	—	0.003
J & k	9.6	0.4	10.0	60	4.0	0.001	4.03	0.03
Kerala	9.5	1.2	10.7	50	5.4	0.004	5.4	0.016
Madhya Pradesh	43.1	1.4	44.5	40	26.7	4.22	22.5	1.00
Madras & Pondicherry	12.9	3.5	16.4	30	11.5	3.47	8.00	2.30
Maharashtra	19.8	1.2	21.0	40	12.6	3.41	9.2	2.00
Mysore	14.8	1.8	16.6	40	10.0	1.03	9.0	0.75
Punjab	5.1	4.0	9.1	25	6.9	3.3	3.6	3.5
Orissa	19.4	3.4	22.8	30	16.0	0.15	15.8	0.20
Rajasthan	4.0	1.8	5.8	40	3.4	2.07	1.4	3.00
Uttar Pradesh	34.5	10.0	44.5	20	35.5	17.92	17.6	9.00
West Bengal	19.6	3.4	23.0	30	16.1	0.36	15.7	0.10
Total	299.8	44.3	344.1		218.8	46.76	170.8	27.00

*All units in million acre feet unless otherwise stated.
**Distribution on the proportional rate of the total irrigated area by canals in each State.
n.a.—not available.

(3) Assessment of the existing quantum of annual utilisation of groundwater separately for each river basin and sub-basin for (i) irrigation, (ii) industrial uses, and (iii) domestic supplies;
(4) Assessment of additional groundwater requirements for the above three items for full development of (a) existing projects, (b) projects currently under execution, and (c) committed projects;
(5) Determination of the unutilised groundwater resources in each basin and sub-basin, after meeting the aggregate current utilisation and after making a provision for the additional requirements for existing and committed projects;
(6) Assessment of the future utilisation of the surplus groundwater resources in each basin and sub-basin with due consideration for the recharge and depletion of the groundwater table;
(7) Compilation of currently available data regarding the behaviour of groundwater table in different basins and sub-basins. Study of the year to year fluctuations and of the general behaviour of the ground water table in different river basins;
(8) Assessment, on the basis of the above studies, of the ultimate utilisation and of surplus groundwater in each river basin and for the country as a whole; and
(9) Preparation of groundwater maps giving information regarding depths to water table, yield and quality of water in aquifers, etc.

3.47 In the course of our tour we saw a set of excellent maps for each village and group of villages (Taluk) prepared by the Groundwater Directorate of the Mysore Government. We commend the efforts of this Unit. The ETO has also attempted to prepare groundwater reservoir maps indicating groundwater occurrence in various parts of the country. The GSI has recently produced a Groundwater Map of India. But for purposes of actual exploitation what is needed is a series of detailed maps for each locality. The Commission hopes that the State Groundwater Units will take urgent steps to prepare such maps on the basis of a specific programme. While preparing such maps preference should be given to the mapping of drought affected areas.

Utilisable Water Resources

3.48 So far, no systematic study or analysis of the utilisable water resources of the country has been done except for the Indus river system. Some preliminary studies have, however, been carried out in respect of the Godavari, the Krishna, the Narmada and the Tapi rivers. According to data now available, the entire water resources of these rivers can be utilised. The waters of the Cauvery have been practically fully utilised.

As regards the Ganga, which carries about 493,400 m. cu. m. (400 MAF) of water, on an average, it should be possible to utilise about 185,000 m. cu. m. (150 MAF) for irrigation development. In view of the topography and the limited opportunities for storage, the rest of its waters will continue to flow into the Bay of Bengal, particularly during the monsoon season.

There is very little possibility of utilising the Brahmaputra waters except through a few medium and lift irrigation schemes in Assam. Nearly 370,000 m.cu.m. (300 MAF) of Brahmaputra waters will continue to flow annually into the Bay of Bengal.

The west flowing rivers of India (excluding the Tapi and Narmada) are another important and significant source of water. These rivers carry, on an average, nearly 246,700 m. cu. m. (200 MAF) of water. However, on account of the very short distances traversed by them in their flow to the coast and the nature of the terrain, the possibilities of utilising these waters for irrigation are very limited. It is, however, possible to divert eastward a limited quantity of water from these rivers for irrigation. Nearly 197,400 m. cu. m. (160 MAF) however will still continue to flow into the Arabian Sea.

The Mahanadi, and other east flowing rivers have a sizeable water potential though only partial utilisation would be possible on account of the limited land potential and storage possibilities. About 74,000 m. cu. m. (60 MAF) of water of these rivers would still flow into the Bay of Bengal.

3.49 The utilisable water resources of the country can thus be broadly summed up as shown below :

(1) Narmada, Tapi, Godavari, Krishna, Cauvery and other Southern rivers.	246,700 m. cu. m. (200 MAF)
(2) The Indus System	49,300 m. cu. m. (40 MAF)
(3) The Ganga System	185,000 m. cu. m. (150 MAF)
(4) The Brahmaputra System	12,300 m. cu. m. (10 MAF)
(5) The Mahanadi and other east flowing rivers	123,400 m. cu. m. (100 MAF)
(6) West flowing rivers excluding the Tapi and Narmada	49,300 m. cu. m. (40 MAF)
Total	666,000 m. cu. m. (540 MAF)

3.50 In Table 3.5 Dr. Raghava Rao and his colleagues have worked out the annual draft of ground water based on the average area irrigated by each well and the total number of open wells, private tube-wells and State tube-wells. In addition to irrigation wells, there are a number of wells and tube-wells for water supply, constructed by the Public Health Engineering Departments, Municipalities and Panchayat Samities. Railways and industrial establishments also have their own wells and tube-wells. The draft due to such type of wells is also to be taken into account while working out the ground water resources available for irrigation. The draft, at present, on account of domestic and industrial uses is estimated to be of the order of 65,000 m. cu. m. The ground water resources available for irrigation and future draft from domestic and industrial wells, may be of the order of 204,000 m. cu. m.

CHAPTER IV

PROGRESS OF IRRIGATION—A REVIEW

We propose to review the progress made by public and private irrigation works in three phases: before 1900 when the First Irrigation Commission was set up; from 1900 to 1950 and after 1950.

4.2 References to irrigation abound in the folk-lore and ancient literature of the country. Historical records bear testimony to the existence of a number of old works in different parts of the country. The character of these works was largely conditioned by the physiographical features of the area in which they were located. In the arid and semi-arid plains of north India, perennial rivers like the Indus and the Ganga made it relatively easy to divert flood-flows through inundation channels. In the peninsula, where the rainfall is scanty, the practice of trapping storm-water in large tanks for domestic and agricultural purposes was wide-spread. In areas where a high ground water table permitted lift irrigation, wells were common.

4.3 With the advent of British rule, irrigation attained great importance. Much was done to repair and improve some of the more important old irrigation works. A number of new works, some of them unique in design, were also undertaken to harness the flows in the major rivers. The Government provided credit and assistance for the construction of private wells, etc. By the time the British withdrew, the country had built up an unrivalled irrigation system. Some of the works represented significant contributions to the science and technology of irrigation.

4.4 With the partition of India, the irrigation works were divided between the two successor States, but the distribution of irrigated area was far from even. India got more than its share of population, but less than its due share of land resources. It was deprived of the surplus grain-producing areas and most of the Indus irrigation system. As a result it became an importer of foodgrains. It was obvious that little could be done to increase production unless steps were taken to reduce the country's dependence on the monsoon. Hence, in the development plans which Independent India formulated, irrigation received high priority. Commendable progress has been made in the last 25 years.

DEVELOPMENT OF IRRIGATION DURING THE 19TH CENTURY

Public works

4.5 The irrigation works in existence at the beginning of the 19th century included innumerable wells all over the country, a large number of tanks in south India and several inundation canals in north India. The Viranarayana and Gangaikonda-Cholapuram tanks in Tamil Nadu and the Anantaraja Sagara in Andhra Pradesh were constructed as early as the 10th and 13th centuries, respectively. The Grand Anicut built in the 2nd century A.D., was by far the greatest engineering feat of ancient India. It was irrigating over 0.24 million hectares at the beginning of the 19th century. The Western and Eastern Yamuna Canals on the Yamuna and the Hasli Canal on the Ravi were dug during the 14th to 18th centuries. Some of them earned sizeable revenues for the State. The Hasli Canal, for instance, irrigated over 12.5 thousand hectares in 1849 and earned Rs. 76,000.

4.6 Irrigation development under British rule began with the renovation, improvement and extension of existing works, like the ones mentioned above. When enough experience and confidence had been gained, the Government ventured on new major works, like the Upper Ganga Canal, the Upper Bari Doab Canal and the Krishna and Godavari Delta Systems, which were all river-diversion works of considerable size. The period from 1836 to 1866 marked the investigation, development and completion of these four major works. Thereafter there was some slackening in tempo for a couple of decades. Attracted by the profitability of the first major irrigation works, two private companies planned irrigation development on a grandiose scale. Their aim was to link Karachi via Kanpur, Calcutta and Cuttack to Bhatkal, Mangalore and Madras. But all that they were able to achieve was a series of disconnected waterways, like the Midnapur Canal, the Orissa High-Level Canal and the Kurnool-Cudappah Canal. The venture ended in failure and had to be taken over by the Government. This episode led to a policy review and it was decided that, in future, irrigation development would be undertaken exclusively by the Government.

4.7 These two companies nevertheless left their mark on irrigation financing. For their capital they had depended on public loans. This method of raising capital came to stay. The Government adopted the practice in 1867, in respect of works which promised a minimum net return. Certain safeguards were subsequently built into the system

as a result of the recommendations made by a sub-committee appointed by the British Parliament. Thereafter, a number of projects were taken up. These included major canal works like the Sirhind, the Lower Ganga, the Agra and the Mutha Canals, and the Periyar irrigation works, and smaller works like the Penner River Canals (Andhra Pradesh), the Hathmati Canal (Gujarat), the Ekruk Tank and the Lakh Canal (Maharashtra). Some other major canal projects were also completed on the Indus system during this period. These included the Lower Swat, the Lower Sohag and Para, the Lower Chenab and the Sidhnai Canals, all of which went to Pakistan in 1947.

4.8 The recurrence of drought and famines during the second half of the 19th century necessitated the development of irrigation to give protection against the failure of crops and to reduce large scale expenditure on famine relief. As irrigation works in low rainfall tracts were not considered likely to meet the productivity test they had to be financed from current revenues. Following the great famine of 1876-78, a special fund of Rs. 15.0 million, known as the Famine Relief and Insurance Fund, was set apart every year from 1882. Half of it was earmarked for the development of railways and irrigation, if it was not spent on famine relief. But the only significant protective works constructed during the period were the Betwa Canal in Uttar Pradesh, the Nira Left Bank Canal, the Gokak Canal and the Mhaswad Tank in Maharashtra, and the Rushikulya in the Orissa area. Between the two types of works viz. productive and protective, the former received greater attention from the Government.

4.9 The gross area irrigated in British India by public works at the close of the 19th century, according to the First Irrigation Commission, was about 7.5 million hectares. Of this 4.5 million hectares was from productive and protective works and 3 million hectares from minor works like tanks, inundation canals etc. for which no separate capital accounts were maintained. The area irrigated by protective works was only a little more than 0.12 million hectares.

Private works

4.10 Wells, together with private canals, tanks, streams and channels constituted the category of private works. Wells accounted for the major share of irrigation. Private works had been aided by the State from times immemorial, but a definite policy emerged only after the Famine Commission of 1880 recommended taccavi loans for the construction of wells etc. In 1883, the Government of India enacted the Land Improvement Loans Act, enabling it to advance money for specific land-improvement

purposes. This was followed by the Agriculturists' Loan Act in 1884. There was, however, no uniform implementation of these Acts, and performance varied from province to province. The extent of taccavi loans made available depended upon the initiative of district officers. The system of tenancy also inhibited the disbursement of loans. The measures, therefore, produced only a moderate impact on irrigation development. The area irrigated by private works in British India around 1900 was 5.7 million hectares, about 70 per cent of it by wells and the remaining by tanks, streams, channels etc.

4.11 The total irrigated area (from all sources) in 1900 was 13.4 million hectares of which public works accounted for 56 per cent. The gross area sown was 82.2 million hectares of which about 16 per cent was irrigated. Source-wise, canals irrigated 45 per cent of the area, wells 35 per cent, tanks 15 per cent and other sources 5 per cent.

IRRIGATION DEVELOPMENT—1900–1950

The First Irrigation Commission and its recommendations

4.12 The First Famine Commission of 1880 emphasised the need for direct State initiative in the development of irrigation, particularly in the vulnerable areas. It also recommended that irrigation be given priority over other competing fields, such as the railways. However, for nearly two decades no serious action was taken by the Government to formulate a comprehensive plan of irrigation development, presumably because of the complacency engendered by the comparatively good agricultural years from 1880 to 1895. The two great famines of 1897–98 and 1899–1900, however, left the Government with no alternative but to initiate protective measures against drought and famine over large areas. The Government had, by this time, become fully aware that such works were indispensable, even though most of them were expensive and unremunerative.

4.13 The First Irrigation Commission was appointed in 1901 to report on irrigation as a means of protection against famine in India. Its terms of reference have been reproduced in Chapter I. The Commission made a thorough review of irrigation development in the Provinces and examined proposals for new schemes. It suggested a number of measures to stimulate the construction of private works, and drew up a 20-year plan envisaging an expenditure of Rs. 440 million on public works to irrigate 2.6 million hectares.

Major Public Works

4.14 The more important public works recommended by the Commission were the following:

(1) Bombay-Deccan:

(i) Chankapur storage on river Girna and Maladevi storage on river Pravara.

(ii) Storage works on the river Gujauni to feed the Nira Right Bank Canal and on the Ghataprabha to feed the Gokak Canal.

(iii) Catchment areas of all rivers originating in the Western Ghats to be investigated for locating as many storage reservoirs as possible to provide irrigation to scarcity tracts.

(2) Madras:

(i) Improvement of the Kurnool-Cudappah Canal.

(ii) Storage works on the rivers Cauvery and Krishna (about 210 kilometres upstream of Vijayawada).

(iii) Investigation of the Tungabhadra Project.

(3) Central Provinces:

(i) Suitable works on the rivers Narmada, Mahanadi and Wainganga.

(4) United Provinces:

(i) The Ken canal.

(ii) The diversion of Sarda waters into the Ganga above the Narora weir, to release a portion of the supply in the Ganga. Part of the supplies to be utilised for extending irrigation to Bijnor and Budaun districts and the balance to be used for augmenting supplies to the Agra Canal via the Hindon river, and to the Eastern Yamuna Canal.

(5) Bengal-Bihar:

(i) Investigation of storage and diversion schemes on the river Karamnasa for irrigating parts of Shahabad.

(ii) Postponement of the Bagmati Canal Project in favour of smaller works like the Kamla in Darbhanga.

(6) Gujarat:

(i) Location of suitable storage sites on the rivers Sabarmati, Mahi and Narmada.

(ii) Implementation of the Tapi Project if it facilitated profitable cultivation of paddy in part of the command area.

4.15 For parts of Punjab and Sind which are now in Pakistan the Commission had recommended four major schemes: (i) the Lower Bari Doab Canal as an inter-basin project, (ii) weirs across the river Sutlej to link all inundation canals on both banks, (iii) a small canal on the river Indus as part of the Sind Sagar Scheme and (iv) feasibility studies for a

permanent weir across the river Indus in Sind. The Commission also recommended a number of small works. which could conveniently be taken up for famine relief in the rice growing districts of the Central Provinces and in Chhota Nagpur, Bundelkhand, Berar and Gujarat.

4.16 For the Princely States. besides making general proposals for storage works in the western region of Mysore and in the Telangana area of Hyderabad. the Commission recommended that a comprehensive survey be made of the river basins of the states of Rajputana. Central India. Kathiawar and Gujarat.

Private Irrigation Works

4.17 The Commission attached considerable importance to the development of private irrigation works which accounted for 44 per cent of the irrigated area. Its suggestions for assisting and stimulating their development included the following:

(i) Liberalising the system of taccavi advances for agricultural improvements including the sanction and recovery of such advances.
(ii) Reducing the rate of interest on loans to 5 per cent.
(iii) Giving grants-in-aid for land improvement works including wells, in the tracts affected by famine.
(iv) Giving partial remission of loans for wells etc. in case of a failure to strike water.
(v) Mapping all tracts where well-irrigation was feasible and providing boring tools etc. at nominal rates.

4.18 Almost all the major recommendations which were made in respect of Bombay. Deccan. Madras. United Provinces and Punjab had been implemented before Independence in full. or with some modifications. though delays had occurred in some projects due to factors like the intervention of two World Wars, inter-State Province disputes, and changes in the Government's irrigation policy. Irrigation projects recommended for Gujarat. Bihar and most of the former Princely States, and on the Narmada river in the Central Provinces. however, remained unimplemented for one reason or the other. Although the First Irrigation Commission attached great importance to protective works in famine-stricken areas. interest in them gradually tapered off. after an initial show of concern. Irrigation works in the Punjab. however. continued to receive favoured treatment throughout. presumably because of their profitability and the opportunities which they offered for colonisation. Mysore and Hyderabad implemented the storage works recommended by the Commission.

Progress of Public Works : 1900–1950

4.19 Following the First Irrigation Commission's Report. an accelerated construction of public irrigation works began in 1905–06 when an outlay of Rs. 12.0 million was incurred on productive and protective schemes. By 1911–12 the annual expenditure had risen to Rs. 28.6 million and continued at a little below that level in the next two years. The outbreak of the First World War in 1914. however, necessitated drastic cuts. Nevertheless, the annual capital expenditure on public works almost doubled between 1900 and 1920.

4.20 Besides the five protective works mentioned in Para 4.8, four more were either under construction, or had been completed as famine relief works, when the Commission signed its report in April, 1903. These were the Tribeni and Dhaka Canals in the Champaran district in Bihar, the Chankapur Tank in Bombay, and the Khairabanda Tank in the Central Provinces.

4.21 The Irrigation Commission had directed that special attention be given to Bundelkhand and the Mirzapur-Allahabad area of the United Provinces. The important works constructed in Bundelkhand included canals like the Pahuj-Garhmau, the Dhasan and the Ken, and a work on the Majhgawan Tank, together with several small storage reservoirs. In the Mirzapur-Allahabad area, which had no public works before 1900, three large projects were constructed. These were the Ghagar, Ghori and Sukhra in Mirzapur, of which the first was by far the most important.

4.22 Other area in which a number of protective and productive works were constructed during this period were the Nagpur and Chattisgarh plains of Central India. These areas had remained free from drought till 1897, but were badly affected from 1897 to 1903. Most of the works taken up in this area were tanks, the largest of them being the Ramtek Tank in Nagpur district.

4.23 In the Bombay Province, the Chankapur-Girna System and the Pravara and the Godavari Canals were completed, and work on the Nira Right Bank Canal was taken in hand, as recommended by the Commission. The Nira Project, however, took many years to complete.

4.24 The total capital outlay on protective irrigation works increased sixfold from Rs. 20 million in April, 1903 to about Rs. 120 million in April, 1921.

4.25 Among the important productive (as distinct from protective) works completed or begun during this period were the Mahanadi and Wainganga Canals in the Central Provinces and the Sarda-Kicha Feeder in the United Provinces. The Triple Canals, the Lower Jhelum Canal, the Dad Canal and the Upper Swat Canal were the important works completed on the Indus System.

4.26 The overall outlay on public irrigation increased from about Rs. 400 million in 1901 to Rs. 790 million in 1920–21.

4.27 The area irrigated by public works in British India (excluding the princely States) increased to 10.4 million hectares in 1920–21. The total area irrigated by both public and private works rose to 19.3 million hectares. The total irrigated area in the country, including the Princely States added up to 22.6 million hectares.

4.28 In 1921 the constitutional reforms brought about a transfer of powers to the Provinces. In the next 10 years, a number of works which had been started earlier were completed, and several new projects were sanctioned in the Provinces and Princely States. These included the Cauvery-Mettur Project in Madras, the Sutlej Valley Project in Punjab, the Sukkur Barrage in Sind, the Nizam Sagar Project in Hyderabad and the Krishnaraja Sagar Project in Mysore. Another project taken up during this period was the Damodar Canal in 1926–27 in Bengal.

4.29 The earlier concern for protective works slackened. For example the Nira River Valley Project for the protection of Sholapur district made very slow progress and took over 20 years to complete despite the fact that the constitutional reforms of 1919 had authorised Provincial Governments to raise loans for protective works if they could not be financed from current revenues or from the Famine Insurance Fund. By 1935, the Sarda Canal and all the other projects mentioned above were completed, making a significant addition to the irrigated area.

4.30 The Government of India Act of 1935, which placed the Irrigation Department under the control of popular Ministers, became operative from April, 1937. It was expected to speed up irrigation development in the Provinces. But the outbreak of the Second World War in 1939, led to the resignation of the Congress Ministries in six major Provinces and placed severe restrictions on expenditure. As a result, there was a virtual stoppage of all works not directly related to the war effort. Only improvements to existing works and small projects of local importance were taken up. An exception was made in respect of two major projects in the

Punjab viz. the Thal and the Haveli, the first of which had been recommended by the Irrigation Commission. Both projects are now in Pakistan.

4.31 The average area irrigated per annum by Government works in British India during 1941-45 was 13.6 million hectares of which nearly three-fourths was irrigated by canals. This accounted for an increase of 30 per cent over the area irrigated in 1920-21. Of the total, nearly half the area was in Pakistan. Important public works costing more than Rs. 10 million each constructed in India during the pre-Independence period are listed in Appendix 4.1.

Progress of Private works

4.32 Despite the various incentives recommended by the First Irrigation Commission for the promotion of private works, particularly wells, the Royal Commission on Agriculture appointed in 1928 did not find any significant expansion in well irrigation. The area irrigated from wells in British India was 4.68 million hectares in 1902–03 and it was only 4.73 million hectares in 1925–26. There were fluctuations in the area irrigated by wells during this period, from year to year, but a sharp increase was recorded in drought years. For example, it was as much as 5.75 million hectares during each of the drought years 1907–08, 1918–19 and 1920–21.

In Punjab and Uttar Pradesh there was a steady decrease in well irrigation due to the extension of canal irrigation. The Royal Commission found a large number of abandoned wells in different areas where there had been a fall in sub-soil water, or disputes over supplies following the sub-division of holdings etc. As a way out, the Commission suggested the cooperative sinking and working of wells, and recommended that a special enquiry be made into the causes, in areas where the number of abandoned wells was large. The Commission reiterated the recommendation of the Irrigation Commission, that systematic surveys of sub-soil water should be organised, and that taccavi assistance should be given liberally to farmers.

4.33 The tapping of falls on the Ganga Canal for power generation in the thirties gave a fillip to lift and tubewell irrigation in west Uttar Pradesh. During the years from 1931 to 1934, nearly a hundred successful tubewells were sunk in the Meerut, Moradabad and Bijnor districts. In 1934, the Provincial Government decided to sink and energise tubewells at its own cost to irrigate the dry tracts of west Uttar Pradesh, wherever canal irrigation was either impossible or difficult. A comprehensive survey was made of suitable sites for tubewells and a project for

1500 tubewells at a cost of nearly Rs. 12.6 million was planned. By April, 1936 there were 743 tubewells in different parts of Uttar Pradesh and their number increased to 1474 in 1939.

4.34 Encouraged by the example of Uttar Pradesh, Punjab also started prospecting for groundwater sources in the semi-arid areas of Gurdaspur and in the upper reaches of the Western Yamuna Canal, with considerable success. Significant progress has been achieved since then in tubewell irrigation, not only in these two States but in other States, too. Between 1930 and 1940, the area irrigated by wells in the British Provinces registered an increase of about 17 per cent, from 4.75 million hectares to 5.57 million hectares and those from all sources other than Government Canals by 13 per cent, from 10.8 to 12.2 million hectares.

4.35 The Famine Enquiry Commission of 1944, which was appointed to investigate the Bengal Famine, made a thorough assessment of the food situation in the country. It was clear that if agricultural production was to keep pace with the growth of population, it was not enough to extend irrigation through public projects, but private works would have to be greatly expanded, too. The recommendations made by the Commission in this regard were, by and large, a reiteration of the recommendations of the Irrigation Commission and the Royal Commission on Agriculture, with the minor difference that tanks were placed at par with wells, and all the important recommendations applicable to wells were made applicable to tanks. It also suggested the strict enforcement of the existing legislative measures to ensure the proper maintenance of tanks and similar private irrigation works.

4.36 The Grow More Food Campaign launched in 1943 and subsequently integrated with the First Five Year Plan, had for the first time, placed greater reliance on minor works. Large sums were made available as taccavi loans; in addition grants-in-aid to the extent of one-fifth of the cost of a work were given (subject to a maximum), irrespective of whether the area was susceptible to drought or not. The problem of derelict wells and tanks received greater attention. The tubewell construction programme received a new stimulus in States like Uttar Pradesh, Bihar, Punjab and Gujarat.

4.37 The average area irrigated from wells and other private works in British India around 1945 was about 5.6 million hectares and 4.4 million hectares respectively. Well irrigation thus accounted for the major share of irrigation from private works. The total area irrigated in British India was about 23.5 million hectares of which more than 8.0 million hectares were in the area now constituting Pakistan.

Partition and its Consequences

4.38 The net irrigated area in the Indian sub-continent, comprising the British Provinces and Princely States, during the triennium 1944-47 was about 28.2 million hectares, the largest in any country of the world. It amounted to nearly one-fourth of India's cultivated area. Source-wise, 54 per cent of the area was irrigated by canals (mostly Government owned), 23 per cent by wells, 12 per cent by tanks and 11 per cent by other miscellaneous sources. The partition of the country brought about sudden and drastic changes. The following table indicates the net result of partition on the apportionment of the sown area and the irrigated area. between India and Pakistan.

Table 4.1
Net sown area and irrigated area in India and Pakistan on the eve of Partition
(Average for 1944–45 to 1946–47)

(Million hectares)

	Net sown area	Net irrigated area	Col. 3 as % of Col. 2	Area irrigated by					
				Govt. canals	Pvt. canals	Canals (Total)	Wells	Tanks	Others
1	2	3	4	5	6	7	8	9	10
India	98.5	19.4 (100)	19.7	6.3 (32.5)	1.9 (9.8)	8.2 (42.3)	5.3 (27.3)	3.3 (17.0)	2.6 (13.4)
Pakistan*	18.3	8.8 (100)	48.1	6.8 (77.2)	0.2 (2.3)	7.0 (79.5)	1.3 (14.8)	— —	0.5 (5.7)
Undivided India	116.8	28.2 (100)	24.1	13.1 (46.5)	2.1 (7.4)	15.2 (53.9)	6.6 (23.4)	3.3 (11.7)	3.1 (11.0)

Figures in brackets give percentages to the total.
*Figures for Pakistan are estimated figures.

4.39 Eighteen per cent of the population of undivided India and 23 per cent of its geographical area went to Pakistan. Although the cultivated area which went to Pakistan. was about 16 per cent of the total, most of it either enjoyed irrigation facilities or an assured rainfall. On the other hand, the areas which fell to India's share, contained a higher proportion of poor quality land located in areas of precarious rainfall and with little or no irrigation.

4.40 The irrigated area in undivided India constituted 48 per cent of the total cultivated area. On partition, Pakistan received 31 per cent of

this. Major canal systems including the Sutlej and Indus Systems fell to Pakistan's share.

East Bengal, now Bangladesh, which comprises the fertile Ganga-Brahmaputra delta region of Bengal, also went to Pakistan. This area is situated in the assured rainfall zone which produces good crops of rice and jute. The area under rice, wheat and foodgrains as a whole, which went to Pakistan, formed 32%, 35% and 25% of the respective totals in undivided India. The irrigation works which remained with India, barring some of the old works in Uttar Pradesh and in the deltas of the south, were mostly of a protective nature, meant more to ward off famine than to produce significantly higher yields. It was estimated that prior to partition, the portion of undivided India which later on comprised the Indian Union, depended on the areas transferred to Pakistan to the extent of about 1 million tonnes of foodgrains annually. The country had, therefore, no option but to make heavy investments in irrigation in order to increase production.

Trends in Irrigated Area in Indian Union—1900 *to* 1950

4.41 The net areas irrigated from different sources since 1900, in the areas now comprising the Indian Union, are not available from published statistics. An attempt has been made to work out these figures from published data relating to undivided India and the results are indicated in the table below.

Table 4.2

Net area irrigated in Indian Union from 1910 to 1950 (Quinquennial averages)

(Million hectares)

Period	Area irrigated from		Total (all sources)	Irrigated area as per cent of sown area
	Government canals	Wells		
1	2	3	4	5
1910–11 to 1914–15	4.0	4.4	14.5	17.9
1915–16 to 1919–20	4.1	4.7	15.7	19.0
1920–21 to 1924–25	4.4	4.7	16.0	17.4
1925–26 to 1929–30	4.6	4.8	16.2	17.1
1930–31 to 1934–35	5.0	4.8	17.1	17.6
1935–36 to 1939–40	5.6	5.2	18.0	18.6
1940–41 to 1944–45	6.0	5.4	19.0	19.2
1945–46 to 1949–50	6.4	5.3	19.4	19.1

As comprehensive irrigation statistics were compiled only from 1908–09 onwards the relevant information for the first decade of the century has been excluded. The data for individual years shows considerable fluctuations but certain broad trends can nevertheless be seen.

During the four decades from 1910 to 1950, the net area irrigated increased from about 14.5 million hectares to 19.4 million hectares, i.e., by 34 per cent. The area irrigated by Government Canals steadily went up from 4.0 million hectares to 6.4 million hectares or by 60 per cent. Though the area irrigated by wells, showed an overall increase throughout the period, the pace of progress was slow and unsteady, indicating that either promotional measures were not as effeciive as for the development of canal irrigation, or that other factors like the decreasing efficiency of wells over the years, and their eventual lapse into disrepair, had an inhibiting influence on the growth of well irrigation.

The linear growth rate of irrigation during the period has been estimated at 2.00 per cent per annum in respect of the area irrigated by Government Canals, 0.54 per cent in respect of well irrigation and 0.98 per cent in respect of irrigation from all sources. Nearly 19 per cent of the cultivated area was irrigated at the close of this period. There had, however, been some variations in this percentage over the period, partly due to the instability of the irrigated area, and partly due to an increase in the area under cultivation in some years.

PROGRESS OF IRRIGATION UNDER THE FIVE YEAR PLANS

Major and Medium Projects

4.42 The net area irrigated in the Indian Union in 1950–51 was 20.85 million hectares. As 1.71 million hectares were irrigated in more than one crop season, the total extent of gross irrigation was about 22.50 million hectares. There were sizeable periodical additions to the cropped area, particularly after 1949–50, and the result was that the proportion of irrigated area to cropped area dropped to about 17.6 per cent. Much of the new land brought under the plough was of marginal quality, and did not promise any sizeable yields.

4.43 The Planning Commission recognised the crucial importance of developing irrigation to increase agricultural production, and accordingly assigned a very high priority to it in the Plans. A large number of proposals had been investigated as part of the post-war reconstruction programmes, or earlier, and some were taken in hand immediately. These included giant schemes like the Bhakra-Nangal, the Damodar Valley and Hirakud. The first of these had been under the consideration

of the Government in some form or other since 1908. Nearly Rs. 800 million had already been spent on these projects in the pre-Plan period, before their formal inclusion in the First Plan.

4.44 Many more major and medium schemes were included in the First Plan. Including the pre-Plan schemes, there were in all, about 267 schemes under implementation, of which 27 were major projects. Important among the major projects were the Nagarjunasagar in Andhra Pradesh, the Kosi in Bihar, the Chambal complex in Rajasthan and Madhya Pradesh, the Harike in Punjab, the Tungabhadra, an inter-State Project originally of Madras and Hyderabad, now shared by Mysore and Andhra Pradesh, the Bhadra and Ghataprabha in Mysore, the Lower Bhavani in Tamil Nadu, the Matatila in Uttar Pradesh and the Mayurakshi in West Bengal. The aggregate irrigation potential of these works was estimated at 8.9 million hectares, against which the First Plan sought to achieve an additional irrigation of 3.44 million hectares. The actual achievement was, however, only 1.25 million hectares, against the additional irrigation potential of 2.63 million hectares. The total cost of irrigation projects included in the First Plan was Rs. 7,900 million. The outlay of these amounted to Rs. 800 million and Rs. 3,000 million during the pre-Plan and the First Plan respectively.

4.45 Irrigation schemes taken up in the Second Plan included 195 new works with an ultimate potential of 6.1 million hectares. Of these projects, 25 belonged to the category of major works. These included the Rajasthan Canal, the inter-State Gandak Project in Bihar and Uttar Pradesh, Tawa in Madhya Pradesh, Ramganga in Uttar Pradesh, Parambikulam Aliyar in Tamil Nadu, Kabini in Mysore, Kangsabati in West Bengal, Kadana, Ukai and Broach (Narmada) in Gujarat and Purna, Girna, Mula and Khadakwasla in Maharashtra. The projects in Uttar Pradesh, Madhya Pradesh and Gujarat were among those recommended by the First Irrigation Commission. The cost of the Second Plan schemes was estimated at Rs. 6,100 million, and together with a carry forward expenditure of Rs. 4,100 million on First Plan schemes, the total cost of irrigation schemes during the Second Plan came to Rs. 10,200 million. The actual expenditure incurred was Rs. 2,700 million on First Plan schemes and Rs. 1,100 million on Second Plan schemes, i.e., a total of Rs. 3,800 million, leaving a balance of about Rs. 6,400 million to future Plans. The target for major and medium schemes in the Second Plan was 4.21 million hectares; the achievement was 50 per cent of this.

4.46 In view of the carry-over of a large number of schemes, great emphasis was placed on their completion in the Third Plan. Only nine

new major schemes were taken up, the most important of them being the storage scheme on the Beas in Punjab. The Malaprabha and the Upper Krishna were the two other important Third Plan projects, both in Mysore. About 86 medium schemes of local importance were also included. The cost of these new schemes was estimated at Rs. 3,640 million. The total expenditure incurred during the Third Plan period on all schemes, including those continuing from the First and Second Plans was Rs. 5,830 million. As against the target of 5.2 million hectares, the actual additional irrigation realised was only 2.1 million hectares.

4.47 During the triennium 1966–69, for which only Annual Plans were formulated, most of the States were pre-occupied with the irrigation schemes already in hand. Maharashtra, however, launched six new schemes, mainly to extend irrigation to the drought-affected areas of the State. They were Bhima, Jayakwadi, Krishna, Warna, Upper Godavari and Kukadi. The total outlay on irrigation works during this period was Rs. 4,140 million.

4.48 In view of the large number of uncompleted major and medium schemes continuing from Plan to Plan, the progress so far made by the projects was subjected to a thorough scrutiny, and provision was made in the Fourth Plan for their early completion. The total cost of the continuing schemes and the expenditure incurred on them before 1968–69 were estimated at Rs. 24,600 million and Rs. 12,000 million, respectively, indicating a spill-over of Rs. 12,600 million. A total outlay of Rs. 7,710 million is earmarked in the Fourth Plan for these continuing schemes. It includes full, or nearly full, provision for completion within the current Plan period, of all medium and major schemes in the cost range of Rs. 50 million to Rs. 200 million. It is also proposed to take up new schemes estimated to cost Rs. 7,500 million, most of them in the latter part of the Fourth Plan. An additional provision of Rs. 1,400 million has alsc been made in respect of these new schemes. The total provision made in the Fourth Plan for major and medium irrigation works, including investigation of schemes, is Rs. 9,540 million. It is expected that 4.8 million hectares of additional irrigation potential will be created during the Fourth Plan, of which 3.8 million hectares will be put to use during that period.

4.49 In the First Plan, flood control was treated as part of irrigation and hence no separate provision was made. The disastrous floods of 1954 underscored the need for effective measures to mitigate flood damage. The problem, therefore, received increasing attention in the succeeding plans. As against an expenditure of Rs. 130 million on flood control

during the First Plan. about Rs. 480 million was spent in the Second Plan, Rs. 820 million in the Third Plan and Rs. 430 million during the 3 years 1966-69. The Fourth Plan makes a much bigger provision of Rs. 1,330 million for flood control schemes.

Increase in irrigation by major and medium schemes

4.50 Of the 22.6 million hectares of gross irrigated area in 1950–51, major and medium schemes accounted for 9.7 million hectares or 43 per cent of the total. The remaining area was commanded by minor works like wells. tubewells. tanks. etc. By the end of First Plan the area irrigated by major and medium works increased to 11.0 million hectares; at the end of Second Plan to 13.1 million hectares; and at the end of the Third Plan to 15.2 million hectares. registering an overall increase of 57 per cent or about 3.8 per cent per annum. Although during this period a potential for irrigating another 1.4 million hectares had also been created, it could not be utilised due to factors such as the absence of field channels, land shaping etc., which will be discussed in greater detail in Chapter VII. An additional irrigation of 1.7 million hectares was expected during the period 1966–69. The Fourth Plan envisages a further increase of 3.8 million hectares, which will raise the total irrigation from major and medium sources to over 20.0 million hectares.

4.51 The following table gives the targets fixed for major and medium works and the achievements under the different Plans :

Table 4.3
Targets and achievements under the Plans in respect of Major and Medium irrigation works

(Million hectares)

Period	Plan target	Potential created	Actual utilisation achieved	Total area irrigated (gross)
1	2	3	4	5
Pre-Plan	—	—	—	9.7
First Plan	3.4	2.6	1.3	11.0
Second Plan	4.2	2.0	2.1	13.1
Third Plan	5.2	2.3	2.1	15.2
Annual Plans (1966–69)	2.5	2.0	1.7*	16.9*
Fourth Plan	4.8	—	3.8*	20.7*

*anticipated.

Major irrigation projects taken up under the Plans are listed in Appendix 4.2.

Minor Irrigation

4.52 Reference has already been made to the emphasis on irrigation under the Grow More Food Campaign launched in 1943, and finally integrated with the First Plan. After a review of irrigation performance carried out by the Union and State Governments before the commencement of the First Plan, the programme was given a compact area-approach with a big tubewell component. The Grow More Food Enquiry Committee recommended in 1952, that priority should be given to new minor irrigation schemes, and to the repairing of existing works. Minor flow-irrigation schemes were recommended for a still higher priority.

4.53 The Committee also suggested that substantial Union Government funds should be earmarked for minor works of high priority. The bulk of the Union Government Assistance to agriculture during the First Plan was, therefore, devoted to minor irrigation programmes in the States. An important scheme taken up during the period, was the construction of tubewells with foreign assistance. In order to mobilise public cooperation and to involve the Community Development Organisation at the district level, the allocations for minor irrigation in the Second Plan were made partly under the Community Development Programme and partly under the agricultural programmes of the States. The outlays on minor irrigation during the First and Second Plans were Rs. 550 million and Rs. 950 million, respectively.

4.54 The Third Plan laid greater stress on various aspects of the minor irrigation programme, including maintenance, repair, renovation, full utilisation of the existing works, and the peoples' participation in the construction of new works. Problems like salinity and waterlogging in irrigated areas also received attention. The Third Plan outlay on minor irrigation was Rs. 2,700 million. As a result of these measures the area irrigated by wells during this period showed a distinct increase.

4.55 The tempo of progress was further accelerated during the triennium 1966–69. In the years 1965 to 1967, owing to the failure of the south-west monsoon over most of the country, crops were destroyed, and supplies of food, fibre, oil seeds and other raw materials became scarce, creating an economic crisis of unprecedented magnitude. Nevertheless, encouraged by the technological possibilities held out by the new high-yielding cereal varieties, the country made a determined effort to accelerate the minor irrigation programme.

4.56 During these 3 years, about 600 thousand new wells were constructed, raising the total number of wells in the country to 5,700 thousand. Large numbers of diesel pump sets were installed, raising the total number from 465 thousand to 650 thousand. The number of electric pumps, whose running cost is lower, went up from 514 thousand to 1,021 thousand. The number of wells improved by boring or deepening was nearly doubled. There was also a significant increase in the number of both private and public tubewells.

4.57 The total outlay on minor irrigation in the three Annual Plans came to about Rs. 3,140 million. Substantial financial support to the programme was given by institutional credit agencies, like the Agricultural Re-Finance Corporation, the Land Development Banks, the Central Cooperative Banks, and the Agro-Industries Corporations. The following table indicates the progress achieved in the construction of wells and tubewells, installation of pump sets and improvements to existing works during the Plans ending 1968–69 :

Table 4.4
Progress of Minor Irrigation Programmes

(Numbers in thousands)

Item	Pre-Plan	End of First Plan	End of Second Plan	End of Third Plan	End of 1968-69 (anticipated)
1	2	3	4	5	6
Wells in use	NA	3642	4474	5111	5707
Boring of wells	NA	NA	109	245	507
Deepening of wells	NA	NA	14	101	216
Diesel pumps	66	123	230	465	650
Electric pumps	19	50	192	514	1021
Private tubewells including filter points	21	30	49	113	271
State tubewells	3	7	10	13	16

NA = Not available.

4.58 The Fourth Plan envisages the integrated use and efficient management of both ground and surface water resources, extension of irrigation from existing works, major, medium or minor, and the construction of new projects in areas susceptible to drought. Programmes for minor irrigation are to be dovetailed with rural electrification schemes for energising clusters of wells and tubewells. While subsidies are likely to be further reduced, there would be a larger availability of institutional finance for private works.

4.59 Suitable organisations are proposed to be set up in the States and the Union Government to survey and exploit ground water resources. The physical targets in the Fourth Plan are : the construction of a million wells, 375 thousand private tubewells and 6 thousand State Tubewells; boring and deepening of 510 thousand and 350 thousand wells respectively, and the installation of 600 thousand diesel pumps and 1.25 million electric pumps. The total outlay proposed on these programmes is about Rs. 5,160 million. In addition, funds to the extent of Rs. 6,500 million are expected from institutional sources, including Commercial Banks and another Rs. 3000 million from the farmers' own resources. A part of the provision made for rural electrification will also be available for the energisation of pump sets.

Increase in irrigation by minor works

4.60 The area irrigated by minor works, prior to planning, was 12.9 million hectares. The first three Plans aimed at doubling the area of irrigation under minor works. Against a cumulative target of 13.27 million hectares, the achievement at the end of the Third Plan was 12.66 million hectares—very close to the target. However, only about 60 per cent of this increase was contributed by new irrigation, the rest being in the nature of supplemental irrigation, stabilisation of existing irrigation, benefits from drainage, embankments, etc.

4.61 In minor irrigation, the depreciation of existing works is an important factor. Wells fall into disuse after some time; works like tanks, gradually lose their irrigation capacity through siltation; and the discharge of tubewells gets reduced by gradual deterioration of strainers. Losses on account of these factors amounted to roughly 45 per cent of the new irrigation created. As a result, the net addition to the irrigated area during the first Three Plan periods was only 4.11 million hectares or about one-third of the overall achievement reported. The gross area irrigated from minor works at the end of Third Plan was 17 million hectares, which showed an increase of 32 per cent over 1950–51. Wells which are the most important constituent of the category of minor works showed a much higher increase. A further addition of 2 million hectares was expected during the three years 1966–69. The Fourth Plan envisages an increase of 3.2 million hectares.

4.62 The following table shows details of the progress of minor irrigation schemes in the Plans :

Table 4.5
Achievements under Minor Irrigation Schemes

(Gross area in million hectares)

Period	Plan Target	Achievements		Deprecia-tion of existing works	Net in-crease in irrigation	Area irri-gated at the end of the period
		New irrigation	Overall, including indirect benefits			
1	2	3	4	5	6	7
Pre-Plan	—	—	—	—	—	12.90
First Plan	4.45	2.02	3.84	0.86	1.16	14.06
Second Plan	3.64	2.02	3.64	1.29	0.73	14.79
Third Plan	5.18	3.44	5.18	1.22	2.22	17.01
Annual Plans (1966–69)	4.25	2.71	4.21	0.69	2.02	19.03
Fourth Plan (anticipated)	—	4.80	7.20	1.60	3.20	22.23

Overall progress in Irrigation since Independence

4.63 The gross irrigated area of India has increased by 46 per cent as a result of efforts made after Independence to develop major, medium and minor irrigation. From the bench-mark level of 22.6 million hectares it steadily increased to 28.0 million hectares in 1960–61, and to 33.13 million hectares at the end of 1967–68. Over 50 per cent of this net increase was accounted for by major and medium works.

4.64 The areas irrigated source-wise and crop-wise during the years 1950–51, 1955–56, 1960–61 and 1967–68 are shown in tables below:

Table 4.6
Area irrigated source-wise

(Thousand hectares)

Source	1950–51	1955–56	1960–61	1967–68
1	2	3	4	5
Government Canals	7,158 (34.3)	8,025 (35.3)	9,170 (37.2)	10,279 (37.3)
Private Canals	1,137 (5.5)	1,360 (6.0)	1,200 (4.9)	1,025 (3.7)

Table 4.6—Contd.
Area irrigated source-wise

(Thousand hectares)

Source	1950–51	1955–56	1960–61	1967–68
1	2	3	4	5
Tanks	3,613	4,423	4,561	4,599
	(17.3)	(19.4)	(18.5)	(16.7)
Wells	5,978	6,739	7,290	9,264
	(28.7)	(29.6)	(29.6)	(33.7)
Others	2,967	2,211	2,440	2,356
	(14.2)	(9.7)	(9.8)	(8.6)
Total (net irrigated area)	20,853	22,758	24,661	27,523
	(100.0)	(100.0)	(100.0)	(100.0)

Note : Figures in brackets indicate percentage to total net irrigated area.

Table 4.7
Area irrigated crop-wise

(Thousand hectares)

Crop	1950–51	1955–56	1960–61	1967–68*
1	2	3	4	5
Rice	9,844	11,035	12,523	13,861
	(43.8)	(43.0)	(44.7)	(41.8)
Wheat	3,402	4,150	4,233	6,457
	(15.1)	(16.2)	(15.1)	(19.5)
Jowar	463	625	655	707
	(2.0)	(2.4)	(2.3)	(2.1)
Total cereals	16,378	18,643	20,166	21,094
	(72.6)	(72.7)	(72.1)	(72.7)
Gram	974	1,191	1,107	1,249
	(4.3)	(4.6)	(4.0)	(3.8)
Total pulses	1,939	1,983	1,899	2,010
	(8.6)	(7.7)	(6.8)	(6.1)
Total food-grains	18,317	20,626	22,065	26,104
	(81.2)	(80.4)	(78.9)	(78.8)
Sugarcane	1,183	1,274	1,674	1,530
	(5.2)	(5.0)	(6.0)	(4.6)
Condiments & spices	**	215	417	517
		(0.8)	(1.5)	(1.5)

Table 4.7—Contd.
Area irrigated crop-wise

(Thousand hectares)

Crop	1950–51	1955–56	1960–61	1967–68*
1	2	3	4	5
Total fruits & vegetables	**	134 (0.5)	477 (1.7)	663 (2.0)
Groundnut	**	89 (0.3)	195 (0.7)	413 (1.27)
Total oilseeds	**	288 (1.1)	421 (1.5)	753 (2.3)
Cotton	465 (2.0)	834 (3.3)	967 (3.4)	1,285 (3.9)
Other crops	2,598 (11.6)	2,271 (8.9)	1,950 (7.0)	2,280 (6.9)
Total (Gross irrigated area)	22,563 (100.0)	25,642 (100.0)	27,980 (100.0)	33,132 (100.0)

*Provisional
**Included under other crops.
Note : Figures in brackets indicate percentage to gross irrigated area.

4.65 Net additions to irrigation during this 18 year period were of a higher order than those in the preceding 40 years. For the first time the area irrigated by wells rose at a faster rate than that by Government Canals. The contribution by Government Canals and wells was about equal. The linear rate of growth in the net area irrigated during the Plan period, viz. 1950–51 to 1967–68, has been estimated at 2.05 per cent compared to 0.98 per cent during the preceding 40 years. Similar growth rates in respect of areas irrigated by Government Canals and wells were 2.91 per cent and 2.94 per cent, respectively, as against 2.00 per cent and 0.54 per cent, respectively, during the earlier period.

Total financial outlay on irrigation during the Plans

4.66 The following table shows the total expenditure on irrigation programmes, including minor irrigation and flood control, under the first three Plans and the Annual Plans, and the target for expenditure during the Fourth Plan :

Table 4.8
Outlay on irrigation during the Plans

(Rs. million)

Plan	Major & Medium	Flood control	Minor irrigation	Total irrigation	Total Plan outlay	Proportion of col. (5) to col. (6)
1	2	3	4	5	6	7
First Plan	3,800*	130	550	4,480*	19,600	18.78@
Second Plan	3,800	480	950	5,230	46,720	11.19
Third Plan	5,830	820	2,700	9,350	85,730	10.91
Annual Plans (1966–69)	4,140	430	3,140	7,710	67,570	11.41
Fourth Plan (Proposed)	9,540	1,330	5,160	16,030	159,020	10.08

*Includes Rs. 800 million incurred during the pre-Plan period.
@Does not take into account Rs. 800 million incurred during the pre-Plan period.

Irrigation in the States

4.67 The irrigated area is not evenly distributed over different States. In Madhya Pradesh. Maharashtra. Mysore. Gujarat and Rajasthan only 6 to 12 per cent of the cultivated area was irrigated in 1967–68. The aggregate share of these five States in the country's irrigated acreage was hardly one-fourth. but they together accounted for over half the total area cultivated. Rainfall being inadequate and uncertain over large areas in these States. the development of irrigation is. and has always been. one of their most pressing needs. Andhra Pradesh. Bihar. Haryana. West Bengal and Uttar Pradesh belong to an intermediate group with a percentage of irrigation ranging from 24 to 32. The highest percentage of irrigation in the country is in Tamil Nadu and Punjab. where 43 and 58 per cent respectively of the cultivated area receive irrigation.

4.68 The following table shows net cultivated and irrigated areas in the country State-wise. for the year 1967–68:

Table 4.9
Net area Cultivated and Irrigated, State-wise
1967–68

State	Net area cultivated ('000 hectares)	Net area irrigated ('000 hectares)	Col. (3) as per cent of col. (2)
1	2	3	4
Andhra Pradesh	11,367	3,089	27.2
Assam*	2,393	612**	—
Bihar	8,284	2,011	24.3
Gujarat	9,802	1,108	11.3
Haryana	3,514	1,132	32.2
Kerala	2,129	411	19.3
Jammu & Kashmir	675	278	41.2
Madhya Pradesh	17,797	1,143	6.4
Maharashtra	18,267	1,476	8.1
Mysore	9,987	1,082	10.8
Orissa	5,939	977£	—
Punjab	3,992	2,333	58.4
Rajasthan	15,097	1,865	12.4
Tamil Nadu	6,083	2,629	43.2
Uttar Pradesh	17,467	5,657	32.4
West Bengal ×	5,569	1,478	26.5
Himachal Pradesh	547	90	16.4
Nagaland	47	12£	—
Others	696	140	20.1
All India :	139,702	27,523	19.7

*Includes Meghalaya
**Relates to 1953–54
£ Relates to 1955–56
× Relates to 1964–65
Source : Directorate of Economics and Statistics.

PART II

PLANNED DEVELOPMENT OF WATER RESOURCES
POLICIES AND CONSIDERATIONS IN IRRIGATION
AYACUT DEVELOPMENT
DROUGHT AFFECTED AREAS
IMPROVEMENTS TO EXISTING IRRIGATION SYSTEMS
A PERSPECTIVE OF IRRIGATION DEVELOPMENT
ECONOMICS AND FINANCING OF IRRIGATION WORKS
ADMINISTRATION AND ORGANISATION

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PLANNED DEVELOPMENT OF WATER RESOURCES

The success of agriculture depends on the extent to which the water requirements of crops can be met. This makes the conservation of water, and its judicious and economic use, a matter of the greatest national importance.

5.2 A major responsibility will have to be shouldered by those who are connected with the development of our water resources. There are several factors which will have to be kept in view. These include the net availability of water, its quality, location, distribution and variation; climatic conditions, nature of the soil, competing demands and socio-economic conditions. In dealing with each of these, every effort must be made to make the best use of water, so that the interests of the nation as a whole can be served.

5.3 A comprehensive strategy is needed for the conservation and development of our water resources. Large schemes for water storage involve processes which are often irreversible, and leave little opportunity for subsequent changes except at a prohibitive cost. Besides, there is also a limit to the total number of available dam sites. The absence of a coordinated strategy or faulty planning can lead to a waste of resources, and impose a severe limitation on the benefits which might otherwise have been derived from them.

5.4 An integrated policy calls for attention to irrigation, drainage, navigation, flood control, hydro-electric power generation, water supply for industrial and domestic use, land reclamation, control of water pollution from human, animal and industrial wastes, pisciculture, recreation, and control of ground water levels. If any one of these factors is attended to without regard to its effect on the others, serious conflicts and losses may result.

5.5 Our water resources are insufficient to meet the long-term require-

ments of agriculture, industry and other users. There will thus be increasing competition for available supplies as more and more water gets harnessed and committed. We, therefore, recommend a well-defined policy for the development of the water resources of each region or basin, to obtain the maximum benefit for the largest number of people. At the same time we realise that planning for the development of water resources cannot be rigid. The demand for water and its availability, change with time and at successive stages of development, it is therefore necessary to maintain an intelligent flexibility in planning, to keep pace, not only with changing circumstances, but also with the latest developments in technology.

5.6 Irrigation policies and programmes evolved during the last two decades show considerable awareness on the part of the Union and State Governments, specialists, planners, irrigation engineers and enlightened public on the need for an integrated development. But the scope for improvement is still vast. Greater care should be taken to study all the many complex technical, economic and social implications of systematic development. The outstanding problems should be squarely faced before schemes are actually implemented.

River Basin Plans

5.7 The planning of water resources has to be related to a defined area or region, with due regard to inter-regional needs. A river basin, and in the case of large rivers, a sub-basin, is a natural unit. It has a defined watershed boundary, and within it there is an inter-relationship between the surface and groundwater resources. A river basin, therefore, becomes a suitable unit for planning. An overall plan for the development of water resources requires not only a full knowledge of the quantity, quality, and distribution of water resources, but also an evaluation of land uses and their effects on stream flow and the production and movement of sediments.

5.8 River basins differ in their size and potentialities. As no two basins are alike, each should have its own plan of development. Most of our major rivers are inter-State. As a result, there is competition for river water not only between the various uses within a State but also between riparian States. Where a river basin is confined to a single State, co-ordination of the various needs and uses can be secured at the State level. But in the case of inter-State rivers the problem becomes more complicated, particularly when works have to be located in one State and the benefits accrue wholly or partially to other States.

5.9 We would like to stress that the first step in making plans for the utilisation of the water resources of a basin is an accurate assessment of the available ground and surface water resources. We regret that in the past, most development plans have been formulated on the basis of surface water resources alone, without taking into account the available groundwater supply. There should be, for each basin, a water budget of all sources of water, surface and subsurface. In the nature of things this budget cannot be very precise. Variations occur from year to year, in precipitation, run-off, rate of ground water recharge, etc. But for a macro-design, the average values over a fairly long period, say 30 years or more, should provide workable figures.

5.10 The extent and nature of the utilisation of water induces qualitative and quantitative changes. The dominant use of water in most parts of the country is for irrigation, but in future there is likely to be an increasing demand for municipal and industrial purposes. The discharge of effluents into dwindling streams will affect the quality of their water.

5.11 Basin plans should be formulated on the basis of feasibility studies for individual projects. Detailed investigations may change the scope of a project in respect of its storage capacity and the extent and pattern of water use. This change may alter the basin plan and possibly its programme. The basin plan should, therefore, be reviewed from time to time, modified and brought up to date. This should be a continuing process.

5.12 The Commission recommends the following policy for the formulation of river basin plans:

(a) The basin plan should present a comprehensive outline of the development possibilities of land and water resources to meet the anticipated regional and local needs.

(b) The plan should:
   - (i) indicate a broad frame-work of various engineering works to be taken up in the basin, the reasons why they are preferred to alternatives and the inter-relationship between them;
   - (ii) establish priorities in respect of water use for various purposes;
   - (iii) indicate inter se priority of projects;
   - (iv) indicate the need for earmarking water for any specific future purposes.

(c) The plan should be periodically reviewed and revised as required in the light of changing needs and supplies.

5.13 In formulating schemes the States have not always paid due attention to the overall needs of river basins. Projects have at times been formulated to meet a single purpose without adequate attention to its likely effect elsewhere in the basin. This fragmented approach inevitably creates difficulties. The agency responsible for a major project, whether irrigation or hydro-power, tends to neglect such important functions as water-shed management, pollution abatement, the fostering of fish and wild life, recreation, navigation etc. In the absence of a co-ordinated plan for the development of the basin as a whole, the available water resources cannot be put to the best use.

5.14 The need for co-ordinated basin plans began to be felt in the early fifties. It led to the enactment of the River Boards Act in 1956, empowering the Union Government to establish River Boards to advise State Governments on the regulation and development of inter-State rivers or river valleys. With the experience of the Bhakra, Tungabhadra and Hirakud reservoirs the need for soil conservation measures in the catchment areas became urgent. In 1958 the question of setting up River Boards mainly for the purpose of promoting soil conservation measures was considered. The matter, however, remained under discussion till 1961 and eventually it was decided to set up River Boards for a number of inter-State rivers. But differences had already arisen between some States over sharing river waters and several of them withheld their consent to the formation of the Boards. In 1963, the setting up of these Boards was virtually dropped on grounds of economy and also because technical personnel were needed for the armed forces. As an alternative, it was proposed to entrust the tasks intended for the River Boards to the Central Water & Power Commission (CW&PC). Since then the question of setting up River Boards has remained shelved.

5.15 From 1954 to 1959, the CW&PC undertook the preparation of draft master plans for various river basins. However, this work did not make progress for several reasons, particularly difficulty in obtaining data from the State Governments. The CW&PC made an assessment of the surface water resources of the Mahanadi, Narmada and Tapi rivers but these reports have yet to be published.

5.16 We feel that river basin plans must be prepared if the water resources of the country are to be developed to the best advantage. This can only be done by an organisation vested with adequate statutory authority. We have dealt with this matter in detail in Chapter XIV and have recommended the setting up of a National Water Resources Council and River Basin Commissions to ensure the planned development of

water resources. We are of the opinion that carefully prepared and comprehensive plans, based on adequate data and studies, will minimise inter-State conflicts on the use of water, and make it possible to indicate priorities between projects.

5.17 The water resources of a river basin cannot always be fully utilised in the basin itself. In the case of some rivers, for example, the Ganga, a good deal of the monsoon flows in the lower reaches cannot be harnessed for want of storage sites. At the same time, there are other areas in the country where even the essential requirements cannot be fully met by local resources. We recommend that in any study connected with the development of water resources of a basin, the feasibility of utilising its surplus elsewhere should be given due consideration.

Priority in Water Use

5.18 When there is enough water the problem of ensuring equitable distribution between competing uses does not arise. Every user will get all the water he needs. The main use of water resources has been, and will continue to be, for irrigation. But rapid strides are now being made in industrial development, and with the rise in population and the growth of towns and cities, acute urban water supply problems have already arisen in some areas. In the years ahead more water will be needed for river conservancy, pollution abatement in streams, pisciculture, groundwater recharge, reclamation of land, recreation and the preservation of wild life. We would recommend that these demands should be taken into account in planning for the development of water resources.

5.19 To meet various long term requirements in an orderly manner, there should be an order of priority for water-use. The priority accorded to any particular requirement vis-a-vis others should depend upon its economic contribution and its significance to the well-being of the people. Domestic requirements must be given the highest priority. Because industries make a major contribution to the nation's economy but use a relatively small quantity of water, their requirement should normally have the next priority. Since numerous other factors are involved in determining the location of industries, it becomes difficult to make a long range, or precise, estimate of water requirements for industrial use in different river basins. All the same, it is important to make some estimate, howsoever approximate, and to provide for it in the plan of utilisation.

5.20 Long-term planning for the development of water resources should not only take into account the quantitative water requirements

but should also determine the source, surface or underground, which is best suited to a particular requirement. The quality of water is very significant, and water of a particular quality may not be suitable for one purpose but be good enough for another. Unless water resources are marked for specific purposes, it may happen that a cheaper source gets committed to a purpose which can bear a higher cost, leaving the more expensive source for other purposes to which it may prove burdensome.

5.21 Multipurpose river valley projects offer the best use of surface water resources; but apart from situations where both power generation and irrigation may be possible, there may be other cases in which a choice has to be made between the use of water either for irrigation or power generation. The Western Ghats offer sites with high heads for the generation of cheap hydro-electric power by diverting westwards the waters of east flowing streams. In Maharashtra, part of the waters of the Koyna, a tributary of the Krishna, has already been partly diverted westwards to generate hydro-electric power at the Koyna power-station, which has an installed capacity of 560 MW. In such cases, where a choice is involved, the priority has to be determined not only by economic considerations, but by recognition of the fact that irrigation is possible only by the use of water, whereas power can be generated from alternative sources such as coal, gas, oil and atomic fuels.

5.22 In view of the overall scarcity of water resources, we recommend that wherever a choice has to be made between irrigation and power generation, preference should be given to irrigation. The east flowing rivers rising in the Western Ghats traverse areas which have low rainfall and suffer from water scarcity. The needs of these areas should receive priority. It is interesting to note that the United States Bureau of Reclamation considers* irrigation of paramount importance in the planning of multiple-purpose projects, and nowhere in its policy-making legislation does the Bureau accord recognition to power production as a function superior to the use of water for irrigation.

Formulation of Irrigation Schemes

5.23 The pre-Independence river valley projects were mostly single-purpose; but the urge to derive the maximum benefit from the water resources of rivers inevitably led to the concept of multiple-purpose projects. Such projects not only provide maximum service but also reduce

*UN LECTURES—Formulation and Economic Appraisal of Development Projects—Book II.

costs. For example, a flood-control or storage irrigation scheme which by itself may be too expensive, can become economical if combined with schemes for industrial or municipal water-supply or hydro-power generation. The Commission is glad to note that the concept of multiple-purpose river valley projects is now well recognised. The Bhakra-Nangal, Hirakud, Tungabhadra, Chambal, Parambikulam Aliyar, Bhadra, Matatila, Ramganga, Mayurakshi, Kosi and Gandak projects are examples of such schemes. Most of them combined irrigation and power generation. The Damodar Valley scheme, the Hirakud dam and the Kosi project were undertaken essentially for flood control, but were made multiple-purpose schemes to obtain the maximum benefit and to make them economically viable. Some of the multiple-purpose projects already constructed bestow benefits on more than one State. We hope that where overall national considerations demand it, such projects will be formulated to serve more than one State, and parochial considerations will not be allowed to stand in the way.

5.24 Large irrigation projects involve a number of major policy decisions, some socio-economic and some technical. It is important that in formulating a scheme, these decisions should be taken at the earliest and at a competent level, so that the waste of effort involved in making subsequent changes is avoided. Early confirmation should be obtained regarding the mode of irrigation, whether intensive or extensive, the extent of lift irrigation to be provided and the conjunctive use of ground water.

Cropping Pattern

5.25 The cropping pattern in a commanded area is generally worked out on the basis of a study of soils, climate, rainfall, existing cropping patterns and the marketability of produce. So far, it has been the practice for irrigation engineers to determine the cropping pattern in consultation with the Agriculture Department before they finally obtain the latter's formal approval. We are of the view that in future the Agriculture Department should be made responsible for conducting research, and evolving the cropping pattern in consultation with irrigation engineers. In States where there is a large irrigation programme, it would be a good arrangement to have a separate wing in the Agriculture Department, headed by a senior officer, to deal exclusively with these matters, as in Maharashtra.

Fixing Channel Capacities

5.26 Different methods and norms are in use for fixing capacities

of irrigation channels in different States. These are generally based on past experiments and experience and do not take into account the systematic research work now being done on the water requirements of crops.

5.27 In Haryana, channel capacities are generally based on a water allowance at outlets, of 2.75 cusecs per 1000 acres of culturable command area, to which channel losses are added. Punjab and Rajasthan follow a similar procedure.

In Uttar Pradesh, the channel capacities are fixed on the basis of outlet factors of 32 acres per cusec for rabi crops and 22 acres per cusec for rice, and so on. For rabi channels, allowing 25 percent loss in channels and assuming that watering is done at intervals of 3 weeks, the discharge at the distributary head is worked out by dividing the area by 72. A similar procedure is followed for kharif channels as also in making allowance for irrigating sugarcane.

In Bihar, the water requirement on a channel during any month is worked out on the basis of duties for various crops from past experience. The distributary is designed for the maximum water requirement during any month of the year, making allowance for channel losses.

In Maharashtra, the irrigation requirement in a crop season, in terms of cusec days, is arrived at by dividing the irrigated area by four. The rotation period is taken as 12 days. The discharge requirement at outlets is thus arrived at by dividing the irrigated area by 48. The channel capacity is fixed for the highest of the discharges in the three seasons viz., kharif, rabi and hot weather.

In Gujarat, duties for each crop are fixed in consultation with the Agriculture Department. The water requirement is worked out fortnight by fortnight for all the crops during a crop season. The channel is designed for the maximum requirement during any fortnight in the year, after making due allowance for transmission losses.

In Andhra Pradesh, Mysore and Tamil Nadu, duties are based on past experience and the characteristics of the command area separately for wet and dry (light irrigated) crops. Channels are designed on the basis of these duties.

Other States follow more or less a similar pattern, based on their past experience of water use by different crops.

5.28 The best period for sowing wheat in most parts of northern India is the fortnight from the 8th November to the 22nd November for all varieties of seeds, though it may be stretched by another week. If the sowing is delayed beyond 3 weeks after the 8th November, the yield may drop by even as much as 3 quintals per hectare per week's delay. The presowing watering for wheat is generally required 8–10 days

before sowing. The first watering of this crop, known as *kor* watering is crucial. It is required three weeks after sowing at crown root initiation stage. A delay in this watering results in serious reduction in yield which may be even as much as 5 quintals per hectare per week's delay, in the case of high yielding varieties. If channel capacity is adequate for the *kor* watering, it would be sufficient for subsequent waterings.

5.29 The considerations for fixing the capacity of channels for the irrigation of rice are different. The rice crop requires standing water in the field and the daily requirement is determined by the aggregate loss through evapo-transpiration and percolation from the field. The percolation loss in most rice areas is more than double that of evapo-transpiration. The permeability of the soil is thus a major factor to be considered in fixing the capacity of a rice channel. As soils vary from place to place, there can be no uniform norm of water requirements for rice. The water requirement for puddling operations for transplantation, is generally substantially higher than for subsequent waterings. The best period for transplanting rice in most parts of the country is the month of July. A delay of 15 days in this operation beyond the end of July, we were told, may reduce yields by 15 to 20 per cent and a delay of one month by 40 per cent, particularly in season-bound varieties and where climatic conditions play a vital role in controlling the yield of rice. Irrigation channels for rice areas have thus to be designed to meet the irrigation requirements of puddling and transplantation in the appropriate period under adverse rainfall conditions. The channel-capacity thus determined would be more than adequate for subsequent irrigation requirements.

5.30 Irrigation channels which have to serve concentrated sugarcane areas have to have adequate capacity to ensure irrigation of sugarcane fields, preferably at intervals of 10 days and not more than 15 days. During the months of May and June, because of the high rate of evapo-transpiration, the water requirement of the crop is highest.

5.31 Cotton in Rajasthan is generally sown in the month of April while in Gujarat the best period for sowing this crop is between 15th and 30th May. The channel capacities in cotton areas should be adequate to meet the requirements of sowing cotton, as also for irrigating other crops that may be on the ground during that period. Being a deep-rooted crop, cotton can stand a longer interval, upto about a month, between two waterings, except where the soil is very sandy.

5.32 Research on crop-water requirement is being carried out at a number of places, notably at the Indian Council of Agricultural Re-

search (ICAR), Delhi, Rice Research Institute, Cuttack, Hoshangabad, Ludhiana, Coimbatore and many other Agricultural Universities, Colleges and Research Stations. These experiments take into account the soil—plant—water relationship, the useful contribution of rainfall in the crop growth period and the interaction of other inputs like fertilizers etc. In designing future canals, or while remodelling existing canals, the irrigation engineer should take note of these developments, work out the 'duties' and 'deltas' and 'water allowances' afresh and then design the canal systems. There is urgent need for good monographs on the subject so that the results of the research work is available to the practising engineer. We suggest that the CW&PC and the ICAR should make joint efforts to bring out these monographs or 'Design Manuals' and also update them as the research on the subject develops further.

Intensities of Irrigation

5.33 In formulating irrigation schemes it is very important to adopt a correct intensity i.e., the sum total of the area irrigated under different crops in a year, expressed as a percentage of the culturable commanded area. The earlier irrigation works in north India such as the Upper Ganga Canal and the Eastern and Western Yamuna Canals, utilised the run-of-the-river flows and were designed for low intensities in order to irrigate as large an area as possible. These canal systems have been remodelled from time to time, and the intensities obtaining on them at present are; Upper Ganga Canal about 77 percent, Eastern Yamuna Canal about 47 percent and Western Yamuna Canal about 57 percent. The irrigation schemes in the deltas were designed to irrigate rice throughout the ayacut in the kharif season. During the post-monsoon period, the available river flows were utilised to irrigate part of the ayacut and thus intensive of over 100 per cent were obtained.

The determination of a suitable intensity involves a careful consideration of various factors such as. the amount and the nature of available water supply, soil, climate, depth of groundwater-table, natural drainage and socio-economic consideration. Where availability of water is not a limiting factor, the adoption of high intensities is obviously called for. High intensities help the farmer to derive the maximum economic benefit from the land and provide continuous gainful agricultural employment, provided the soils are suitable and the groundwater-table is low enough to preclude the risk of waterlogging. The raising of more than one irrigated crop in any area leads to the better use of inputs like fertilisers and improved implements and also of residual soil moisture from the previous crop.

Intensities in the alluvial plains have to be considered in the light of

their drainage conditions. Where the natural drainage is sluggish because of flat slopes, the groundwater-table is likely to be already high. Adoption of high intensities with surface waters in such areas is fraught with the risk of waterlogging. We are of the view that the best way of attaining high intensities of, say, more than 100 per cent in such areas is by making conjunctive use of surface and groundwater, accompanied by an efficient system of surface drainage. Where natural drainage is good, the risk of waterlogging is less. We feel that intensities of the order of 150 per cent or even more, can safely be adopted in alluvial tracts such as the Indo-Gangetic plain, through the conjunctive use of surface and groundwater. We would like to emphasise that high intensities must be accompanied by efficient drainage.

In areas where the total water resources are limited, the alternatives are high intensity in a part of the area or a low intensity over the whole area. We recommend that in such areas, irrigation should be provided in compact blocks, with intensities which give the maximum economic benefit per unit of water and extend the benefit of irrigation to as large a number of people as possible. This matter is dealt with further in the next chapter.

5.34 Surface water is capable of being conveyed over fairly long distances; but apart from heavy conveyance losses, it may lead to serious problems connected with regulation of supplies, particularly during periods of keen and competing demand. The Sarda Canal Extension, designed to irrigate areas about 500 kilometres away from the source, is a case in point. In order to overcome them it became necessary to formulate the Dalmau Lift Irrigation Scheme. The shortage of water during periods of keen demand in the lower reaches of long distributaries is a common experience on many irrigation systems. More attention should be paid to the problems of regulation while schemes are being formulated.

5.35 In order to prevent the water table from rising to an undesirable level as a result of canal irrigation, we suggest that groundwater should be lifted by tubewells. even though irrigation from surface sources is cheaper. In the Kosi project of Bihar, the groundwater-table has risen in certain areas to a detrimental level and large scale counter-measures are needed to remedy the situation. A similar problem has arisen in parts of Punjab, Haryana and Uttar Pradesh. A combination of surface and ground water irrigation often gives the best results.

5.36 In irrigation projects, due attention should be paid to the drainage problems of the command area, to avoid waterlogging and

its attendant evil. salt efflorescence. In some of our earlier irrigation projects. this aspect had been neglected with the result that hundreds of thousands of hectares of irrigated land have been damaged or rendered completely unfit for cultivation. The States most affected are Punjab. Haryana and Uttar Pradesh. closely followed by Maharashtra.

5.37 In 1959.* the Union Government had advised the States to ensure that drains in all command areas formed part of the irrigation project itself. But only a few irrigation projects formulated in recent years have made adequate provision for drains. Drains by themselves do not yield any direct revenue and are consequently apt to be accorded a lower priority than the irrigation part of the project. An area once damaged by waterlogging and salt efflorescence is difficult and costly to reclaim. We therefore urge that in formulating irrigation schemes, the instructions already issued in respect of making adequate provision for drainage should be strictly enforced.

Conjunctive Use of Surface and Groundwaters

5.38 We have already stressed the need for taking groundwater resources into account while preparing river basin plans. This is particularly desirable where the groundwater supply is ample or where it is expected to improve with the advent of canal irrigation. There are several ways of making combined or conjunctive use of surface and groundwaters. It can take the form of full utilisation of surface water supplies supplemented by groundwater. or the direct use of groundwater during periods of low canal supplies or canal closures. It can also take the form of irrigating pockets exclusively with groundwater in a canal command. especially where the terrain is uneven. Planning for combined use of surface and groundwaters calls for greater ingenuity than is needed for their separate use. It has to be admitted that so far no projects have been planned on the basis of such combined use of water. Such combined use as is now practised was not pre-planned. but has come into being. out of necessity.

5.39 Several of the existing irrigation systems suffer from inadequate supplies. The inadequacy is of two kinds. the first being the lack of timely supplies and the second the inability to provide either the right quantity or the correct number of irrigations needed to raise a good crop. The latter problem generally arises when a canal commands a

*Ministry of Irrigation & Power letter No. DW. II-28 (41)/59, dated 21.7.1959 and Planning Commission letter No. NR-10 (3)/59, dated 29.10.1959.

larger area than it can properly serve. Some of the older systems were designed to provide protection to as large an area as could be commanded, and aimed at giving farmers at least one assured crop in a year. This suited the needs of the time. But recent advances in agriculture. particularly the introduction of the high-yielding varieties of crops require that the supply of water to irrigated crops should be both timely and adequate in depth and the number of waterings. It is in this context that the exploitation of ground water resources in the canal command assumes significance. wherever surface flows are not adequate.

5.40 Conjunctive use has been in vogue for some years now. though to a limited extent. in several parts of the country such as the Cauvery Delta in Tamil Nadu. the Godavari and Pravara Canal Systems in Maharashtra. the Ganga Canal. the Western Yamuna Canal in Haryana and more recently on a large scale in parts of Punjab and Uttar Pradesh.

5.41 In certain parts of the Cauvery Delta. farmers have installed their own filter-points in the irrigated area to raise paddy seedlings early in June before the canal system is opened. The first crop is harvested by the end of September before the onset of the north-east monsoon. A second crop is raised on these lands which is harvested in January or February. The filter-points enable the farmers to give a watering to the crop after the closure of the canals wherever necessary. particularly in areas in the tail-reaches which suffer from scarcity even when canals are open. Some cultivators raise even a summer crop of cotton or groundnut with the help of these filter-points and give irrigation support to sugarcane. Thus. with the conjunctive use of the surface waters of the Cauvery and groundwater. it has been possible for farmers in the Cauvery Delta to raise two and sometimes three crops.

5.42 Under the Pravara and Godavari canal systems in Maharashtra. a number of farmers have constructed masonry wells and installed diesel or electric pump sets to supplement canal supplies for growing sugarcane. In Maharashtra. under the block system of irrigation. the area under sugarcane is restricted and some of the co-operative sugar factories. which find it difficult to sustain production on the limited supplies of cane from block areas. have increased the areas under sugarcane with the help of wells fitted with pump sets. Where canal water is available for 8 months in a year. the demand in the remaining 4 months is met by exploiting the ground water resources of the area.

5.43 In Uttar Pradesh. conjunctive use of surface and groundwater was first made in the early 'thirties', when batteries of tubewells were

installed in the tail reaches of some distributary channels of the Ganga Canal, in Meerut district, to meet the keen demand for water during periods of low canal supply. Normal canal water rates were charged from the irrigators.

5.44 On the Western Yamuna Canal in Haryana a somewhat different arrangement has been adopted for augmenting canal supplies. A number of tubewells have been sunk by the side of the main canal and the water extracted by them is put into the canal. The Jagadhri tubewell scheme introduced in 1949–54 adds about 11.33 cumecs from 256 tubewells, to the flow of the canal. In 1965, the construction of another batch of 128 tubewells was undertaken and there are proposals to sink many more to augment canal supplies during periods of low flow.

5.45 Another useful mode of conjunctive use is the construction of tubewells in irrigation commands to lower the water table, wherever it might have risen as a result of seepage from surface irrigation. The extracted water is used to supplement irrigation supplies as has been done in parts of Punjab in recent years.

5.46 Conjunctive use may play some role in areas with saline aquifers. It is not an uncommon practice in countries like Israel and the U.S.A. to utilise saline groundwater in a limited way for irrigation after diluting the salinity with surface water. There are some crops which can tolerate a fairly high degree of salinity in water, and the water resources, particularly in arid tracts, can to some extent be augmented by the combined use of surface water and saline ground water. This could be done in certain areas of Gujarat and Rajasthan where brackish water has been found. If such brackish water can be combined with the sweet water of canals like the Rajasthan canal, it should be possible to extend irrigation.

5.47 The conjunctive use of groundwater in canal systems can bestow great economic benefits. The Ganga Canal and the Eastern and Western Yamuna Canals, for instance, are fed by diversion works without the backing of storage reservoirs. The groundwater aquifer in such cases serves as a dependable balancing reservoir from which supplies can be drawn to make up deficiencies in river supplies. Studies have shown that any investment on tubewells sunk for this purpose is amply justified by the increased production through higher yields and multiple cropping. Also, returns are immediate, as there is no time-lag in the utilisation of the additional supplies. Nor are any funds required for the development of the commanded area, since it is already under irrigation. All this is of great significance for the speedy growth of our

economy. We therefore recommend that schemes for the conjunctive use of surface and ground waters in existing irrigation systems should be accorded high priority.

5.48 A study of the water resources of the country indicates that certain areas offer large scope for the conjunctive use of surface and groundwater resources. These areas include the Indo-Gangetic plain, the coastal areas of Orissa and Andhra Pradesh, the Cauvery delta and parts of the Narmada basin. Conjunctive use is also possible, though to a lesser extent, in many other parts of the country where open wells or tubewells can be sunk to supplement canal supplies. We recommend that a systematic study should be made by each State, as soon as possible, to identify areas where conjunctive use is feasible, particularly in the commands of existing canal systems.

5.49 Before any large scale programme for the conjunctive use of surface and groundwater resources is under-taken, we recommend that careful investigations should be made to quantify, region-wise, surface and groundwater resources and the inter-action of one source on the other in an integrated development and combined utilisation. It is also necessary to make a cost study of the various alternatives to determine the best mode of conjunctive use in an area.

5.50 In advocating conjunctive use, we are aware that indiscriminate exploitation of ground waters may lead to serious difficulties. It is in this context that the need for legislation to regulate the exploitation of groundwaters becomes important. We are of the view that tubewell construction should be regulated by law in areas where there is a risk of over-exploitation, so that the size and spacing of tubewells is controlled to facilitate the systematic exploitation of the groundwater resources in a particular area. We have dealt with this legislative aspect in Chapter XVI.

5.51 An important problem concerning the conjunctive use of surface and ground waters is the water rate to be paid for the two uses by the farmer. We have dealt with this question in Chapter XI.

Investigation

5.52 An irrigation project requires careful investigation because once it is completed it cannot be easily altered after the subsequent discovery of an error. As most of the future use of surface water is likely to be through storage reservoirs, dams will have to be thoroughly investigated for economy and safety. Should a dam fail it would release a

destructive flood entailing colossal loss of life and property. Many disastrous failures of dams have occurred in the world. India has had its share with eight* failures since 1947. According to a survey in 1961,** of the dams in various countries which met with an accident of one kind or another, 40 per cent had foundation failures and 23 per cent had inadequate spillways, because they had been constructed without adequate investigation and/or sufficient hydrological data. The damage caused by an ill planned canal system may not be as sensational as that caused by the failure of a dam, but its long term effect could be worse. It may render large areas unproductive through waterlogging and salination.

5.53 Hydro-meteorological data are basic to the formulation of river valley schemes. Due to variations in precipitation and river flows from year to year, the data should span a fairly long period, say 30 years, to cover the dry and wet cycles. The longer the period for which data are available, the sounder would be the basis for project formulation. In river basins where hydro-meteorological stations are inadequate, the data for project formulation will also be inadequate. This may in some cases even hold up the preparation of satisfactory project reports. We would, therefore, recommend that without loss of time the adequacy of hydro-meteorological stations in all river basins should be carefully examined and a phased programme prepared for setting them up whereever necessary.

5.54 With rare exceptions, the cost of projects undertaken in recent years has exceeded the sanctioned estimates. In some cases the excess has been abnormal, leading to delay in construction period, the deferment of benefits and the complete distortion of other plan programmes. The rise in the cost of labour and material has no doubt been a contributory factor, but in many cases the excess expenditure was caused by factors which had not been adequately provided for in the estimate. There are always pressures for an early preparation of the project report. We are of the opinion that while investigations should be carried out with all despatch, any attempt to speed up the formulation of a scheme by omitting or curtailing essential investigations is likely to prove wasteful.

5.55 The cost of investigating a river valley scheme is only a fraction

*The dams are Palakmati in Madhya Pradesh (1953), Ahraura in Uttar Pradesh (1953), Arwar in Rajasthan (1956), Gudah in Rajasthan (1956), Kaddam in Andhra Pradesh (1958), Panshet and Khadakwasla in Maharashtra (1961) and Nanaksagar in Uttar Pradesh (1967)—See also proceedings of First Asian Regional Conference of International Society of Soil Mechanics and Foundation Engineering—1960.

**Indian Concrete Journal—June 1964.

of its total cost. Investigations of a dam site require roughly one-half to one per cent of the cost of the dam and in the case of a canal system four to five per cent of its cost. Any stinting on these small outlays can lead to inadequate investigations and faulty preparation of a project or the missing of the best alternative. The more thorough are the investigations, the less will be the necessity for subsequent changes in design during construction.

5.56 There should be a number of fully investigated schemes kept ready for choice. as, otherwise, financial resources may get deployed on relatively uneconomic schemes merely because the more economical ones are not ready for consideration. Most States have established investigating units. but in view of the task ahead many of these units will have to be strengthened. We would like the present position to be reviewed and a programme of investigations drawn up for the next 10 to 15 years.

5.57 Investigations of major and medium irrigation projects are carried out by the State Irrigation Department. These investigations require the assistance of experts in several disciplines such as geology. soils and agronomy. For major projects. at present, a number of whole-time geologists are deputed by the Geological Survey of India or the State Geological Department. The soil surveys and the agronomy studies are generally handled by the Agriculture Department. but coordination between the Irrigation and Agriculture departments in this matter leaves much to be desired. The organisational aspect of investigations has been dealt with by us in Chapter XIV.

5.58 The investigation of irrigation projects and their attendant ayacut development schemes should be undertaken simultaneously. By the time the irrigation project is ready for consideration. the scheme for ayacut development should also be ready. so that both can be considered together. This would enable the necessary financial arrangements for ayacut development to be made. along with those for the irrigation project. Both the irrigation scheme and the ayacut development scheme should indicate the phased requirement of funds. In the case of the latter the amount has to be provided by Government and by financial institutions such as land-development and other banks. We have dealt with ayacut development further in Chapter VII.

5.59 In the case of a storage irrigation scheme. it is important that the life of the reservoir should not be shortened for want of timely soil conservation measures in the catchment area. It is therefore necessary

that conservation studies, particularly for the more critical areas in the catchment, should be taken in hand as soon as investigations concerned with the storage scheme itself are taken up. In order to ensure that investigations in catchment areas are not held up for lack of resources, we recommend that funds for this purpose should be provided by the Union Government as a grant to the State in which the catchment area is located. In certain river valley projects the Union Government has already provided funds for soil conservation measures in the catchment areas. These funds are made available half as a loan and half as a grant to the States concerned. The funds needed for investigation purposes are only a small fraction of the funds required for carrying out the actual measures. We would, however, like our recommendation to be limited to relatively bigger schemes, costing, say more than Rs. 100 million, or schemes in which the storage is more than a billion cubic metres or which would irrigate more than 50,000 hectares. We have dealt with soil conservation measures in catchment areas in Chapter X.

Sanction of Schemes and Implementation

5.60 It is the State Governments which investigate and formulate irrigation schemes and accord administrative approval to them. After a scheme has been fully investigated a project report is prepared. This report is submitted to the CW&PC for technical examination. In the case of medium irrigation schemes costing upto Rs. 30 million, the State Governments are required to furnish only a proforma, instead of a project report, to give abroad outlines in respect of the following:

(i) the basic planning and availability of water;
(ii) the inter-State aspect; and
(iii) any other important factor radically affecting the size and shape of the project.

Larger schemes are examined in the CW&PC in detail. After scrutiny, the CW&PC makes a report to the Technical Advisory Committee on Irrigation, Flood Control and Power Projects of the Government of India. After satisfying itself, on the basis of the scrutiny made in the CW&PC, that

(i) the scheme has been prepared after detailed investigation,
(ii) the scheme is technically sound, the estimate complete and correct, and
(iii) the financial forecast and estimate of benefits to be derived are based on correct data,

the Committee advises the Planning Commission and the Ministry of Irrigation and Power, as to whether it should be considered for inclusion in the Plan. Any further examination of a scheme or reference to the

State Government, where it becomes necessary, is made by the CW&PC.

5.61 The Technical Advisory Committee was initially set up in 1954, and has been reconstituted from time to time. It was last reconstituted* on January 23, 1971.

5.62 Major irrigation works involve large sums of money. They have many complex features. A scrutiny of such works by the CW&PC has proved useful in the past. Also, the machinery of the Technical Advisory Committee for project appraisal plays a useful role in ensuring that only schemes which satisfy the prescribed techno-economic criteria qualify for inclusion in the Plan.

As regards medium schemes which though numerous are relatively simple, a detailed examination is hardly necessary. We recommend, therefore, that detailed scrutiny by the CW&PC should be confined to major schemes, and State Government may furnish information on a proforma in respect of all medium schemes. At present, two proformae are in use for medium schemes; a brief one for medium schemes costing less than Rs. 5.0 million and another, somewhat more elaborate, for schemes costing between Rs. 5.0 million and Rs. 30 million. We would suggest that information bearing on the following aspects of all medium schemes should be furnish to the CW&PC in a single suitable proforma:

(a) Basic planning and availability of water;
(b) Inter-State aspects;
(c) The financial aspects; and
(d) Whether it is a self-contained project or part of a larger scheme.

5.63 Technical sanction to irrigation schemes is accorded by the State Chief Engineer. Some schemes are very large and complex. In some States, the Chief Engineer is assisted in the formulation of schemes by a Committee or Board of experts which includes one or more retired engineers. The Chief Engineer or the State Government, at their discretion, refer the more complex matters to the Committee or Board for advice, but the ultimate responsibility for the technical sanction remains with the Chief Engineer. The Chief Engineer may not accept the recommendation of the Committee for reasons which are recorded. We consider this arrangement satisfactory and recommend it to States which have not so far set up such Committees or Boards.

5.64 While including schemes in the Plan, the Planning Commission

*Planning Commission Resolution No. III-1 (2)/71-I&P.

keeps in view the resources position of the State and the need to maintain its tempo of irrigation development. The inclusion of a scheme in the Plan, however, does not mean that it has to be taken up for implementation in the first or any particular year of the Plan, or that it must be completed during that Plan period. The Plan schemes have to be phased in such a manner that there are no sudden increases in the yearly demand for funds. The available personnel and machinery have to be kept suitably employed. If too many schemes are taken up at one time and the resources are meagre, the construction period for all of them will be prolonged and costs will increase. The Kuttiadi project in Kerala, Salandi in Orissa, Ghataprabha in Mysore, and Hasdeo in Madhya Pradesh, to quote only a few, are examples of projects with abnormally prolonged construction periods. We would like to point out that what matters is not the time when construction commences, but the time when benefits accrue. We recommend that once a project is taken up, it should be implemented at the optimum pace. In this context it is important that a carefully thought out programme for construction and expenditure should be attached to the estimates.

5.65 So that benefits accrue quickly the construction of irrigation channels should start simultaneously with the construction of headworks, both in diversion works and storage dams. Land must be prepared and farmers should be ready to make use of the water as soon as it appears. Such synchronisation did not always exist in the earlier plan projects. For example, in the Gangapur Project, storage was ready in 1954 but could not be utilised till 1958, because canal construction was taken up long after the storage construction. We note with satisfaction that there is now an increasing awareness of the need for synchronisation.

Completion Report and History of the Project

5.66 We are of the view that the project authority should prepare a completion report, setting out the history and the salient features of the entire construction process. For this purpose a proper record should be kept as construction proceeds. This information will be useful in the operation and subsequent modification, if any, of the project. The task should be entrusted to an officer who has worked on the project reasonably long and is fully conversant with its details. In the case of larger projects, it would be desirable to print these reports.

CHAPTER VI

POLICIES AND CONSIDERATIONS IN IRRIGATION

The Role of Irrigation

Irrigation encourages the farmer to adopt more scientific techniques. It enables him to sow the right strains at the right time and realise higher profits. It also permits him to go in for more intensive cropping which creates new opportunities for gainful employment.

6.2 The farmer's attitude to irrigation is determined by its ability to add to his net income. Farmers in zones with adequate rainfall did not, till recently, avail of irrigation facilities to the extent envisaged, because their rain-fed crops gave them reasonable yields. With the introduction of high-yielding varieties this attitude is now changing and the demand for water has risen sharply throughout the country.

Determinants of Irrigation Requirements

6.3 The water requirements of a crop are determined by evapo-transpiration, which is a physical process involving the conversion of water into vapour with the aid of energy derived from the sun. Evapo-transpiration is thus governed, primarily, by meteorological factors. As a consequence, the water requirements of various crops are determined largely by the length of their periods of growth and the seasonal changes in climate. It is independent of crop species except for rice, which has a larger requirement. The nature of soil effects only the frequency and depth of irrigation. Shallow soils require a greater number of light waterings, whereas deeper soils can do with fewer but more intensive irrigations. But in either case the total amount of water required by crops remains the same, provided the climatic conditions are identical.

6.4 The Table 6.1 shows the mean daily evaporation, by months, for the years 1959-1968, for a few representative places in the country.

Table 6.1
Mean Daily Evaporation by Months*

(Inches)

Stations	Months											
	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
New Delhi	3.2	4.4	6.1	10.1	12.0	12.8	6.7	5.0	5.5	6.0	4.7	3.4
Lucknow (Amausi)	2.2	3.9	6.6	9.9	11.4	9.7	6.0	4.7	4.4	3.8	2.9	2.2
Bikaner	2.7	4.2	6.8	9.5	12.2	13.2	9.6	7.8	7.4	6.6	4.2	2.7
Ahmedabad	5.2	6.8	9.1	11.5	13.0	10.4	6.2	4.5	5.5	6.5	6.0	5.2
Gaya	3.2	5.0	7.8	11.6	13.2	10.1	5.4	4.6	4.4	3.9	3.3	2.9
Nagpur	4.0	6.0	7.7	9.9	13.2	9.1	4.7	3.8	4.5	4.9	4.3	3.5
Bombay (Colaba)	3.6	4.2	5.1	5.6	6.0	4.6	3.0	3.0	3.5	4.0	3.7	3.3
Hyderabad (Begumpet)	5.5	7.3	8.9	9.5	11.5	8.9	6.4	5.9	5.4	5.3	5.3	5.3
Madras	4.1	4.9	5.9	6.6	8.3	8.1	6.7	6.3	5.4	4.4	3.8	3.5
Bangalore	4.4	6.3	7.8	7.3	6.4	4.8	3.9	3.8	3.7	3.8	3.6	3.7

**Source* : India Meteorological Department.

Evaporation in the hot months of May and June is two to five times that in the winter months of December and January, and the rate varies considerably from place to place. Irrigation supplies have to be related to the seasons and weather conditions, and should not be assumed to be uniform for the duration of a crop, nor for the same crop in different areas.

6.5 The basic water requirement of a crop is the sum total of the water required for land preparation, percolation, seepage and evapotranspiration, at the optimum irrigation frequency. But in many irrigation systems, the actual amount of water delivered to fields invariably exceeds the basic requirement of the crop. The ratio of water required to water delivered represents the irrigation efficiency in the field.

6.6 In determining the actual irrigation requirement of a crop, the contribution made by rainfall is an important factor. That part of the rainfall which is lost by run-off and by deep percolation is ineffective, and it is only the balance which makes a useful contribution to plant growth. Thus, even light showers which go to make up the moisture deficiency in the root zone of a crop are reckoned as effective rainfall. The irrigation requirement of a crop is thus the total water requirement, minus the effective rainfall and contribution from groundwater through capillary action. The value of effective rainfall varies not only with its amount and intensity, but also with the initial soil moisture deficit, the infiltration rate of the soil and crop management practices.

6.7 To make judicious use of limited irrigation supplies, it is important to determine critical periods during which an insufficiency of moisture in the soil can seriously reduce the yield of crops. In wheat, the flowering and grain-formation stages are the most critical periods for irrigation, in addition to the crown-root initiation stage (21–25 days after sowing). Experiments conducted by the Indian Agricultural Research Institute (I.A.R.I.) in Delhi in 1965 have shown that a faulty irrigation schedule can reduce the yield of Sonora-64 Wheat by as much as 15 quintals per hectare, or 29 percent below the optimum. The results of these experiments are listed in the table below. They clearly show that with the same quantity of irrigation, incorrect application timings can seriously affect yields.

Table 6.2
Response of Wheat (Sonora 64) to Four Irrigation Timings

Number of irrigations during crop-age days			Yield (q/ha)	Relative yield
0–60	60–90	90–120		
—	2	2	37.0	100
1	1	2	44.0	119
2	1	1	51.3	140
2	—	2	52.3	141

For rice, the primordial initiation, flowering and milk stages are the most vital. Lack of adequate moisture at these stages can reduce the yield by as much as 50 per cent. Irrigation systems should thus provide water not only in the required quantity, but at the required time.

6.8 The largest consumer of irrigation water in the country is rice, as would be seen from the Table 6.3.

Rice requires much more water than any other cereal. But the productivity of rice per unit of water is much lower than that of other cereals, as can be seen from the Table 6.4.

However, as a major part of the country's rice is grown during the rainy season in high rainfall areas (1150 mm. and above), the use of irrigation water during its growth period is only supplemental. Moreover, it needs to be noted that in such areas rice and jute are the only two kharif crops that do well. It is evident that the cultivation of rice without adequate support from rainfall, for example in low rainfall areas, or during the

Table 6.3
Cropwise Distribution of Irrigation Water Resources*

Crop	Water diverted (%)
Rice	45
Wheat	15
Other Cereals	12
Pulses	7
Sugarcane	6
Cotton	4
Other crops	11
Total :	100

*IARI—Review of work done on water requirements of crops in India—1970.

Table 6.4
Productivity of Cereals per Unit of Water*

Crop (New Strains)	Water requirement in a typical tract (mm.)	Yield (kg/ha)	Productivity per mm water (kg/ha)
Rice	1,200	4,500	3.7
Sorghum	500	4,500	9.0
Bajra	500	4,500	8.0
Maize	625	5,000	8.0
Wheat	400	5,000	12.5

*IARI—N.G. Dastane on New Concepts in Irrigation.

dry season period, amounts to an uneconomic use of irrigation water. The Commission, therefore, suggests that adequate support from rainfall should be kept in view whilst planning for rice production. It further recommends that a second rice crop, particularly in the non-rainy season, should be grown in an area only if irrigation supplies cannot be put to better use by other crops.

Irrigation of Rice

6.9 There is great scope for further economy in the use of irrigation water for rice production in the command areas of both new as well as existing projects. Recent experiments for determining the water requirements of rice on loamy soil, showed that out of 1680 mm. of water needed

by the crop, 1200 mm. was lost by percolation and only 480 mm. met the crop's actual consumption. On heavier soils, the percolation losses are smaller. This highlights the magnitude of percolation losses in relation to the consumptive use of water by the rice crop. It also brings out the need for an accurate assessment of percolation losses, in order to obtain a clearer picture of the water requirements of rice in project areas. Rice cultivation should ordinarily be earmarked for heavier soils, since lighter soils lead to wastage through excessive percolation. The following norms have been suggested by the IARI for the cultivation of rice under irrigated conditions :

Soil class	*Percolation per day (mm.)*
Excellent	1.0–2.5
Good	2.5–5.0
Marginal	5.0–10.0
Unsuitable	More than 10.0

6.10 In many parts of south-east Asia, with rice soils consisting of heavy clays with low permeability, the wet season water requirement for peak yields is as low as 650 mm. This is considered sufficient for essential land preparation, unavoidable percolation and seepage and evapo-transpiration at potential rates. The daily water requirements of rice depend upon climate, and the permeability of the soil. The total water requirement of the crop is a function of the time that it takes to mature. The actual amount of water used under most irrigation systems in India is far in excess of the actual requirement. It is often as high as 2500 mm. or more. Water used in excess of the actual requirement of the crop is a loss, a considerable part of which can be avoided. Many cultivators apply large doses of water to their rice fields in the mistaken belief that it will result in higher yields. Research shows that submergence of land is beneficial to the rice crop, but when it exceeds 4 cm. it confers no advantage. It does not lead to higher yields from the Indian varieties, and in the case of the dwarf strains it is actually harmful. In fact, in experiments with the Aus crop, a submergence of even 4 cm. has not given any higher yield than that obtained with only land saturation. At the same time, fields with moisture below the saturation level for more than three days at a stretch, have given considerably lower yields, compared to those that had been submerged. This is brought out by the results of experiments with N.P. 130 and Taichung Native 1, in the Table 6.5.

Table 6.5
Effect of Water regime on Paddy Yields*

Water regimes	Yield of paddy (q/ha)	
	N.P. 130	Taichung Native 1
Field capacity to 0.4 atmosphere tension	46.1	55.8
4–0 cm. submergence	59.0	71.9
8–4 cm. submergence	57.0	56.1

*IARI—Bhatia and Dastane—1966.

It will be observed that in both varieties there is a reduction of one-fifth in crop yield if the water regime is kept below field capacity, and an equivalent reduction in Taichung Native 1, when the water depth is kept in excess of 4 cm. Although conditions in different areas may lead to somewhat different results, the broad conclusions would remain valid. For optimum yields, therefore, the supply of water should be so regulated that the depth of submergence is maintained at about 4 cm.

6.11 Since rice requires more water than any other cereal, care should be taken in multiple cropping programmes that to ensure the second crop is one that requires less water, unless the available supplies would go waste if not used for growing paddy again. By alternating rice with less demanding crops, it should be possible to provide irrigation for a larger gross area.

6.12 The problems relating to economy in the use of water in the field through better water management are dealt with in Chapter VII.

Irrigation in Low Rainfall Areas

6.13 In most low rainfall areas there is scarcity, not only of surface water, but also of ground water. These areas should, therefore, be utilised as far as possible for only such irrigated crops as require less water, give reasonable yields with fewer waterings, and withstand longer dry spells. Also, there should be a careful examination of the pattern of irrigation, with a view to reducing losses, both in the process of conveying water to the field, and in its actual application.

6.14 The IARI has conducted a series of experiments to show

variations in the number of waterings affect wheat yields on sandy-loam soils. The results are listed in the table below :

Table 6.6*
Relative Yields of Wheat (Sonora 64) with Different Number of Irrigations (1966–67)

No. of irrigations	Yield (q/ha)	Relative yields	Best irrigation schedule (days after sowing)
Unirrigated	9.3	1.0	—
One	30.4	3.3	25
Two	34.2	3.7	25, 65
Three	35.4	3.8	25, 65, 105
Four	42.8	4.5	25, 45, 65, 105
Five	47.8	5.1	25, 45, 65, 85, 105

*IARI—Review of work done on water requirements of crops in India—1967.

The table shows that a single irrigation of wheat, 25 days after sowing raises the yield to three times that of an unirrigated crop. The increase in yield from subsequent waterings is not as spectacular. These results, though valid for the particular soil and climatic situation under which the experiments were conducted, indicate that in areas where water is severely limited, as in arid areas, a larger area can be served and more farmers benefited, if the number of irrigations is limited. In deciding the number of irrigations for a crop in such areas, the climate and the capacity of the soil to retain moisture are important considerations. Such an irrigation system would require larger channels to serve a larger area at each watering. The economics of such an arrangement should be carefully investigated.

6.15 Where limited irrigation is desired, the question arises whether irrigation should be done in scattered fields or in blocks. Experiments have shown that an irrigated field, surrounded by other irrigated fields, gives a substantially higher yield than one surrounded by unirrigated fields. Therefore, irrigation is best applied in blocks, rather than in scattered isolated fields. Besides, the network of channels in a compact block would cost less and entail lower losses in conveyance. Although the block system would benefit fewer people than a dispersed system, in our opinion, it should be preferred in the interests of overall economy in cost, and use of water. Where only a portion of the land in a village is brought under irrigation, it would be equitable to allot to each land-holder, portions of both irrigated and unirrigated land, during consolidation of land-holdings.

Policies regarding the Use of Water Resources for Irrigation

6.16 Irrigation policies are shaped by the growing demand for agricultural products. According to demographic projections, by the turn of the century over 900 million persons will have to be fed and clothed. This calls for a judicious exploitation of both land and water resources, and in each region, irrigation policies will necessarily have to take note of the extent to which both are available.

6.17 Broadly, the goals of irrigation policy may be classified under three heads viz.,

(i) maximum production per unit of area,
(ii) maximum production per unit of water, and
(iii) maximum area served.

The Brahmaputra Valley in Assam has high rainfall and plenty of surface and ground water, but very little land. Kerala has a high population density and tiny holdings, but good rainfall. The Indo-Gangetic Plain has a high density of population, good fertile soil and abundant surface and groundwater. In all these areas, water resources are adequate, but land is scarce, and the aim should be to secure the maximum production per unit of area, through multiple cropping, high yielding varieties, and the latest technology.

6.18 In most other parts of the country, water resources are insufficient to meet the irrigation requirements of the cultivated land. About 70 per cent of the cultivated area of India lies in regions of medium and low rainfall. Even in areas of high rainfall, the abundance of water is limited to the short rainy season. Unless rainwater is stored for use later, there would invariably be a scarcity during the dry season. In fact, the only areas with abundant water resources are those parts of the alluvial tracts, which have plenty of ground water. In areas other than those with ample water resources, which we have attempted to define in the preceding paragraph, our policy should aim at securing the maximum crop production per unit of water.

6.19 Low rainfall zones will mostly have rainfed cultivation, and any increase in production will have to come through moisture conservation, the use of drought-resistant varieties, cultivation of pastures etc. But where water can be made available, either from local sources or by transfer from a neighbouring basin, the policy should be to benefit as large a section of the community as possible and at the same time enable farmers to obtain reasonable yields. Surface irrigation systems should be designed to irrigate compact blocks, the blocks being dispersed over

a large area to benefit large numbers of farmers. The number of irrigations can be fewer than are required for high yields. Costly measures to cut down or reduce losses, such as the lining of channels and use of water saving devices like sprinklers and tricklers, would deserve serious consideration.

6.20 In an area with an abundance of both surface and groundwater, the groundwater should be exploited for local use and, if feasible, the surface water transferred to areas less favoured.

Free Choice of Cropping—Block System—Localisation

6.21 Irrigation management systems differ from part to part of the country, since they have been shaped by local conditions, such as the nature and extent of water resources, the soil-climate complex, and the terrain of the irrigated area. The larger irrigation projects taken up in the northern part of India, in the last century, were the Western Yamuna Canal (Haryana) and the Eastern Yamuna Canal (Uttar Pradesh), followed by the Upper Ganga Canal (Uttar Pradesh) and the Upper Bari Doab Canal (Punjab). All these projects drew their supplies from perennial snow-fed rivers, irrigating crops grown all-the-year-round. The areas which these projects served were flat and the soils mostly alluvial. Under these conditions, there was no need for restrictions on cropping, and it was left to the farmer to choose his pattern. Later irrigation projects in the Indo-Gangetic Plain followed much the same practice. A few regulatory measures were, however, adopted. These included a ban on the growing of paddy within half a mile of habitation, as an anti-malaria measure, and an extra rate for irrigating sugarcane from November 15 to January 15, so that larger supplies could be made available for the crucial irrigation of rabi crops during this period.

6.22 In Bihar, a contract system (Satta) was introduced, which required farmers to obtain the permission of the Irrigation Department before they could take water from an outlet. The contract could be for a short period, or for a number of years. In granting permission, the Department exercised its discretion in regulating the cultivation of crops like paddy and sugarcane, with higher water requirements.

6.23 In the south, the earliest large projects were designed for irrigation in the delta areas. They were the Cauvery Delta System (Tamil Nadu) and the Godavari and Krishna Delta Systems (Andhra Pradesh). The large rainfed rivers from which these projects drew their supplies, carried plenty of water during the monsoon months, but dwindled to insignificant

flows in the winter. These systems were, therefore, designed for irrigating only rice. The terrain in the command areas of these projects is flat, and the soils are more or less uniform, enabling a major part of the culturable commanded area to receive irrigation. As a result, in these projects, too, there was no need for restrictions on the cropping pattern. Conditions in the Mahanadi Delta were much the same.

6.24 Irrigation projects in the western parts of Maharashtra, however, are very different. They depend upon storage reservoirs for their supplies, and the canals have to negotiate undulating terrain before they can command sufficient culturable land. The soils vary a great deal in depth and texture. Under such conditions, it is necessary to enforce regulatory measures to ensure the maximum utilisation of water in the kharif season when supplies are plentiful, encourage the cultivation of foodgrain crops with low water requirements during the rabi season, and reduce to a minimum the utilisation of water in summer when evaporation loss is high.

6.25 The ill effects resulting from the uncontrolled cultivation of sugarcane on the Nira Left Bank Canal, and on the Godavari and Pravara Canals had to be controlled by limiting the area under this crop. On the Deccan canals, the growing of sugarcane is now being confined to areas with a soil cover ranging between 0.5 metres and 2.5 metres. Even there, only a prescribed proportion of 1/6 to 1/10 of the commanded area is permitted to be put under sugarcane. On deeper soils, a lower proportion ranging from 1/15 to 1/20 of the area, is permitted, while on soils less than 0.5 metres deep, it is completely prohibited. To enforce regulatory measures, the farmer is required to obtain a sanction for irrigating various crops, and is issued a passbook. Before the start of channel rotation, an irrigation official enters in the passbook the date on which the farmer will get water, and this entitles the latter to irrigate the approved crops on the specified date. Sanctions are generally granted for periods of six years or more. Cropping patterns are sanctioned in compact blocks which vary in size. This system of regulation is called the 'Block System', the blocks being generally named after the important crops grown. The important types of blocks at present on the Deccan Canals are :—

(i) cane blocks,
(ii) fruit blocks,
(iii) garden and seasonal blocks,
(iv) garden blocks, and
(v) new types of two-seasonal blocks.

6.26 With the introduction of storage-supported irrigation projects

in the southern States, regulatory measures became necessary for reasons similar to those in western Maharashtra. The Tungabhadra Project was designed to command a large area, of which only a portion was to receive irrigation. The actual areas which should receive water had, therefore, to be demarcated. As irrigation in these areas was intended to be protective in nature, it was necessary to restrict the area under heavy irrigation, so as to extend its benefits to a larger area. In addition, the commanded area had uneven terrain and black and red soils. For these reasons, areas suitable for heavy irrigation had to be identified and set apart for paddy and sugarcane. The process of demarcating the area for irrigation, that is, of fixing the ayacut, and earmarking areas for specified crops requiring heavy irrigation, light irrigation and perennial supplies, came to be known as "localisation" and was first adopted in the southern States, in the fifties, on the Tungabhadra project.

6.27 With wide variation in India's terrain, soil, climate, water resources and needs, it is not necessary or desirable, to introduce a uniform system of irrigation management on all the projects.

6.28 The absence of restraints on cropping patterns has worked well in our alluvial tracts, because it enables the irrigator to cultivate the most profitable crops. In these tracts, when restrictions become necessary, either because the soil is unsuitable for heavy irrigation or because water is being used wastefully, the constraints should be kept to the minimum.

Irrigation in Black Soils

6.29 The first Irrigation Commission had cautioned against irrigation in black soils of the Deccan trap,* save where the sedimentary deposits were 'not of great depth and where the sub-stratum affords good natural drainage'. Since then, some useful, but uncoordinated research has been done at various institutions, including the IARI, and there has been a slight change in opinion on the subject. At the Agricultural Research Station, Sriguppa, the Commission was informed that on black soils, varying from 1 metre to 2.5 metres in depth, continuous raising of wet and light irrigated crops from 1937 had not developed any salinity. The Regional Research Station, Raichur, broadly confirmed this finding. We were also told that if leaching is practised on irrigated

*Districts outside the Deccan trap, where black soils predominate are Bellary (Mysore), Kurnool, Cuddapah and Telengana region (Andhra Pradesh), Surat and Broach (Gujarat) and Jalaun and Banda (Uttar Pradesh).

black soils once in five or six years, salinity could be further controlled. The Commission noted with interest, that rice and sugarcane cultivation under the old Vijaynagar Canal around Hampi had not developed any sign of salinity during four hundred years of cultivation.

6.30 In the southern States, the heavier black cotton soils are generally located in the valleys, and the lighter red soil higher up. The growing of paddy on lighter soils leads to a comparatively larger consumption of water because of the greater percolation losses. Paddy should, therefore, be localised as far as practicable, on the heavier soils, which are usually situated at lower levels in the valley, and the lighter red soils should be reserved for light irrigated crops. We recommend that this policy should be adopted in new projects, and as far as possible localisation should be revised in existing projects to meet these criteria.

6.31 The efficient utilization of irrigation water involves a study of many factors, including soils, their depth, texture and chemical composition, climatic conditions, the water requirement of different crops, irrigation practices and drainage. The Commission recommends that further studies should be conducted on the suitability of black soils for irrigation in different regions and climates.

Lining of Channels

6.32 In unlined channels, only a portion of the water supplied at the canal head reaches the farmer's field, the rest of it being lost in transit. There is also substantial loss in the field itself, and only a fraction of the supply reaching the farmer's field is actually utilised by crops. Some of these losses are unavoidable. Many of them can, however, be avoided by suitable measures. Losses in channels arise from percolation, evaporation and transpiration from weeds in the canals and on the banks. Little can be done to save the evaporation loss in channels, which in any case is small. On the Upper Ganga Canal, evaporation losses have been estimated at less than one per cent.* Losses due to transpiration through bank vegetation can, however, be reduced by keeping the banks clear of weeds.

6.33 The main loss is through percolation, depending on the permeability of the bed and bank material of the channel. Theoretically, the depth of water in the channel and its temperature affect the seepage rate, but the influence of these factors is relatively small. The commonly

*ICID Annual Bulletin – 1962.

accepted figures for transit losses* in the alluvial plains of north India are 17 per cent for main canals and branches, 8 per cent for distributaries, and 20 per cent for water courses, which gives a total loss of 45 per cent of the water entering the canal head. Then, there are further losses in the field itself, and these have been estimated at 30 per cent of the supply reaching the field, or 17 per cent of the head discharge. In heavier soils the losses are lower, and a channel constructed in clay loam is as good as a lined channel. Losses are heavier on new channels, though in course of time they decrease, as the soil pores get sealed with finer material. The process is more marked, and quicker, in channels that carry silt.

6.34 In designing irrigation channels it is a common practice to assume a channel loss of 2.44 cumecs per million sq. metres (8 cusecs per million sq. feet). With lining, the loss is assumed to fall to 0.15 to 0.46 cumec per million sq. metres (0.5 to 1.5 cusecs per million sq. feet), depending upon the nature of the lining. The application of a norm under similar conditions, such as those in the Indo-Gangetic plain for instance, is in order, but it can be quite misleading when applied to different conditions. In Australia, the losses in a channel constructed in clay loam, were estimated at 0.13 cusec per million sq. feet, as against 35 cusecs per million sq. feet in a newly constructed channel in Aeolian sand, where 80 per cent of the particles were in the range of 0.15 to 0.60 mm. These figures bring out the importance of making soil tests before designing channels and working out the economics of channel lining.

6.35 Besides reducing the percolation losses in channels, lining confers several other benefits. It prevents percolation damage to adjoining agricultural land. Unlined channels have to be designed with wide beds and flat slopes, in order to make them stable. In a lined channel, much higher velocities (nearly three times that of unlined channels) are permissible, and a much deeper and narrower section is adopted. This results in saving on land cost and earth-work. It also reduces the cost of cross-drainage works and bridges, since they are shorter in length; and on steeper terrain there is a saving on canal falls. Lined channels are easier and less costly to maintain, and have safer banks.

6.36 Channels which take off directly from rivers have silty water, and do not present any serious weed problem, but channels which run with clear water drawn from reservoirs, are infested with weeds, which greatly reduce their capacity, and make channel operations difficult.

*Controlling seepage losses from irrigation canals—ICID—1967.

Lining of such channels greatly reduces this evil.

Lining assumes special importance in areas which, on the introduction of irrigation, would be liable to waterlogging and salinity. In all irrigation projects, this aspect should receive careful consideration.

6.37 The importance of lining channels has to be seen in the context of the overall shortage of water resources. A number of lined canals have already been constructed in the country in recent years, for example, the Rajasthan Canal, the Sirhind Feeder, the Bhakra Main, the Western Gandak Canal, the Parambikulam Aliyar System, and the Mahi Right Bank Canal. Unlined canals in India, however, are estimated to carry a discharge of 11,300 cumecs (four hundred thousand cusecs). It has been estimated that lining can save enough water to irrigate an additional six million hectares (15 million acres*). Of course, not all the channels can be lined, for reasons of cost and practicability, but the figures mentioned give some idea of the enormous scope for saving water which is being wasted. In all new projects, the feasibility of lining must be carefully examined.

6.38 In many situations, lining will be found to be amply justified, although the cost of a lined channel may be two to three times that of an unlined channel of an equivalent discharge. In a project area, soils may vary a great deal, and the need for lining can be limited to certain channels, or certain reaches in the same channel. In areas where the percolated water can be economically pumped as ground water, the need for lining has to be weighed against the total benefits accruing from lining, including the prevention of harmful results from seepage. Lining may not be justified where channels run through soils which have very low permeability. Lining must be resorted to where water resources are inadequate and the percolated water cannot be retrieved, or when retrieved, is unfit for use.

6.39 As an alternative to the lining of small water courses, pipelines on the surface or beneath the earth may be worth considering. Though initially more expensive, a pipeline pays for part of its cost by saving land for cultivation which otherwise would be taken up by the watercourse, and by preventing wastage of water which generally occurs as a result of breaches and cuts, and through damage by cattle. In a State like Kerala, where holdings are measured in cents, the use of pipelines is even more relevant. In suitable situations, groups of cultivators can even use portable surface pipes or plastic tubing, which are

*CBI Publication No. 82—Symposium on Canal Lining.

now being indigenously manufactured. These may be moved from field to field, as necessary, and a relatively short length of portable pipe can serve a large area. The use of pipelines is particularly suitable where water is pumped. During our tour in Gujarat we saw that farmers had started using concrete pipes for the distribution of water to different fields. This was particularly marked in such areas as were being irrigated by lifting water from wells. We also saw pipes being manufactured at a number of places on a large scale for use in the irrigation systems.

6.40 In the early stages of a river basin development, water may be plentiful, and the immediate need for saving percolation losses not so urgent. But it must be borne in mind that it may not be possible to provide lining later, especially on larger channels carrying water for the greater part of the year. In determining the economics of lining channels, it would be relevant to consider not only the current value of the water saved, but its value years hence, when new water resources become scarce. The important point to consider is, whether it would be in the overall interest of the nation to forego economy in water use in the initial stage. We, therefore, recommend that the desirability of lining should be carefully studied, when an irrigation scheme is formulated. We further recommend that in all future projects, the main canals and branches should in general be constructed as lined channels, and the lining of distributaries should be undertaken as and when resources become available.

SPRINKLER AND DRIP IRRIGATION

Sprinkler Irrigation

6.41 Several countries have recently taken to sprinkler irrigation on a large scale. In the United States and Russia, about 10 per cent of the irrigated area is sprinkled, while in Israel about 90 per cent is irrigated by this method. In India, sprinkler irrigation was taken up in the early fifties, but, so far, it has not caught on. Sprinkler irrigation requires an initial investment, estimated to be around Rs. 1,750 per hectare, on pumps, pipelines and devices like nozzles or perforated pipes, and in the absence of adequate experimentation and convincing demonstration of its advantages, farmers remain hesitant to adopt it, even in areas where it would be ideal.

Ordinarily, with a limited quantity of water, a substantially larger area can be irrigated by sprinklers than by surface irrigation. This is because percolation losses, both in the water courses and the field, are eliminated, and there is no wastage through run-off. The extent to which

sprinkler irrigation saves water is influenced to a large extent by climatic conditions. Under high temperatures and strong winds, the heavy evaporation losses from the sprinkler sprays substantially reduce the saving in water. Gusty winds also make it difficult to apply water uniformly. In these conditions, sprinkler irrigation is more efficient during the night, when it is cooler and calmer.

Sprinkler irrigation is particularly suited to coarse, sandy and gravelly soils, where percolation losses from surface irrigation are high, and, also, where frequent light irrigation is required because of the poor water-holding capacity of the soil. Sprinkler irrigation is most suitable where the land is undulating or sloping, and the cost of land shaping is high, or where land shaping is not feasible, because of the shallow depth of soils, as in some parts of Maharashtra and peninsular India. In the hills, small streams can be tapped at high levels for irrigating farms lower down with sprinklers, thus doing away with the need for pumping sets to create a head.

Theoretically, sprinkler irrigation can be applied to any crop other than paddy and jute, both of which require copious watering. But its advantages to all other crops are not uniform. Experiments conducted at Anakapalli with sugarcane grown on level and well-prepared fields, showed no special advantage with sprinkler irrigation. At Delhi, the IARI, in experimenting on a potato crop, could irrigate 50 per cent more area with sprinklers than by the furrow method of irrigation. Most coffee and tea gardens are ideally suited for sprinkler irrigation, as they cannot be suitably terraced or shaped for surface irrigation. For coffee it is necessary to have a shower at the flowering stage. If rain fails at the crucial time, a sprinkler is said to be a good substitute. The installation of sprinklers in some coffee plantations is reported to have paid for itself even within a single year, when drought conditions prevailed. Some of the tea gardens have reported a 50 per cent increase in yield, and an improvement in the quality of tea, with the use of sprinklers.

Fertilizers give higher yields when applied in split doses at frequent intervals. Injection of fertilizers in the sprinkler system is a simple and effective way of achieving higher yields at small extra cost. It also permits a better regulation of the dose. Similarly, sprinklers can be used to apply fungicides and weed killers. Sprinklers have yet another use in a sub-tropical climate, where they can be used to protect crops against frost, by spraying water on the plants when the temperature drops below freezing point.

We are of the opinion that there are many areas in the country where the use of sprinkler irrigation would be more useful. A mention has already been made of its suitability for coffee and tea plantations. In areas where the surface water is scarce, and there is a limit to the quantity

of ground water that can be tapped economically, either through tubewells or open wells, we suggest that the feasibility of sprinkler systems should be earnestly studied. For example, in the Gaya district of south Bihar, where there is a scarcity of water, and most of the wells have already been fitted with electric pumpsets, sprinkler irrigation may be of considerable advantage in raising two potato crops in a year. Similarly, for cotton and ground-nut crops in Coimbatore district, sprinkler irrigation may be profitable. Even on canal systems, where the capital cost of irrigation per acre is high, the use of sprinklers may, under suitable conditions help to extend irrigation and improve the economics of a project. The lift irrigation areas on the Rajasthan Canal, particularly the Lunkaransar area, need to be examined for the feasibility of sprinkler irrigation. Some trials are being made with sprinkler irrigation in the coastal areas of Andhra Pradesh, which, if successful, would prove the usefulness of sprinkler irrigation for the sandy coastal tracts.

Where conditions for the use of sprinkler irrigation are favourable, its adoption on the larger farms should present little difficulty. However as most of our land-holdings are small, it may be argued that this factor would make it difficult to introduce the system on a large scale. If the source of supply is a tubewell, or an open well fitted with a pumping-set, the pipelines of the sprinkler system merely replace the water courses, and the arrangement for the distribution of water to individual farmers remains the same. Sprinkler devices, like nozzles or perforated pipes, can be individually owned or community-owned. We are of the view that small holdings do not necessarily stand in the way of introducing sprinkler irrigation where it is otherwise suitable.

Drip (Trickler) Irrigation

6.42 Under this method. irrigation water is conveyed along furrows in 12 to 16 mm. diameter tubings, fed from larger feeder lines, and allowed to drip slowly through nozzles or orifices, at practically zero pressure, to keep the soil surface around the plants constantly wet. This method eliminates the evaporation loss which occurs in sprinkler sprays, and provides steadier wetting of soil. Though more expensive than the sprinkler system is the best method of irrigation with ground water, in arid areas, where soils generally have a high salt content and a poor structure. In drip irrigation, water deficit in the soil hardly occurs because of steady replenishment, and, a poor soil structure therefore ceases to be a major disadvantage. The common assumption in conventional irrigation is, that during the interval between two irrigations, not only do the plant and climate reduce the soil moisture to a point when further application of water becomes necessary, but, due to this loss, the salts in

the remaining water become concentrated until the next irrigation is given. In drip irrigation there is constant wetting, and a high degree of salt concentration is not reached in the root zone.

The drip method of irrigation has been found to be very useful in reclaiming and developing the Arava desert area in Israel. The soil cover, there, consists of wind-blown sand resembling the dune sand typical of desert conditions, with salinity averaging 30 millimhos per cm. The ground water is saline, with an electrical conductivity of 3,000 micromhos per cm. The soil is leached with the saline ground water to reduce its salinity level to about 7 millimhos per cm., a level considered satisfactory for agricultural production under the Arava conditions.

Experiments on a number of crops like tomato, cucumber, musk-melon, pepper, sweet corn etc. showed that in all cases, the yields under drip irrigation far exceeded those under sprinkler or furrow irrigation, and in some cases the yields were more than double, even though the quantity of water applied to any particular crop was, more or less, the same for all the irrigation methods. We have large areas in our country which are arid or semi-arid, with problems similar to those in Israel. In north Gujarat, Saurashtra and Kutch, there are vast stretches of sandy soils which are saline. The tubewell water in north Gujarat and the Little Rann is highly saline. Similar conditions are also met in parts of Rajasthan.

6.43 We are of the opinion that there is need for research, experimentation, and demonstration to identify areas, conditions and crops which are most suitable for sprinkler and drip irrigation; but it should be kept in mind that the location of not all the agricultural universities and research stations is suited for the purpose. It is important that, to begin with, these experiments should be carried out in suitable locations, and on the more promising crops, as otherwise, poor results may dampen further research efforts, and discourage the adoption of these methods.

Lift Irrigation & River Pumping Schemes

6.44 *Manual Lifting of Water*: In the Indo-Gangetic plain, the canals generally irrigate flat lands. Even so, in the command areas of some of the outlets there are portions which are too high for flow irrigation. To irrigate these areas, farmers usually lift water manually, for which they are charged half of the normal water rate, because of the extra labour involved. The farmer takes special care that water is used economically, and that wastage is reduced to the minimum. Experience has shown that the water so saved may be of the order of 20 per cent. The consequent increase in irrigated area partially offsets the loss of revenue by the lower water rate. We recommend that farmers should be encouraged

to lift water for irrigating areas in canal commands which cannot be served by flow.

6.45 *Lift Irrigation from Drains*: Lifting of irrigation water from drains is practised in many parts of the country. Such irrigation is, however, in many cases unauthorised. In the summer months, farmers put up bunds in drains for lifting water, but these bunds are seldom satisfactorily removed before the onset of the rainy season. This leads to obstruction in the flow of rain water. Cases are known where farmers have put up semi-permanent bunds, in order to save the expense and botherance of constructing bunds every year. We see no reason why drain water should not be utilised for irrigation in an authorised manner, but would like to emphasise the need for proper supervision by canal authorities to ensure that drains are not obstructed, and the smooth flow of rain water is maintained. For such irrigation, the farmer should be charged the same water rate as for lifting water from canals.

6.46 Pumping from rivers, streams and lakes for irrigation has been in vogue in India for long. At the turn of the century, several such schemes were in operation. About 10,000 hectares on the Divi Island (Presidency of Madras) were being irrigated by water pumped from the Krishna river. About 1200 to 1600 hectares were irrigated by water pumped from the Kolleru lake. Water was also pumped from the Delta Canals. In all these cases, the lifts were relatively small. Later on, several lift schemes were taken up in the south, and, on a bigger scale, in the north.

6.47 Water can be raised from streams by stationary pumps, or by pumps fitted on boats or mounted on tractors, skids or trolleys. The boat can be stationary or mobile, and the pump may be operated electrically or by diesel power. An outstanding example of a stationary pump lift-irrigation scheme, is the Ramganga Canal in Uttar Pradesh, which was completed in 1935. It has a discharge of 5.6 cumecs (200 cusecs) and irrigates about 14,000 hectares of land. Water is lifted by electric pumps to a height of 11.6 metres, in two stages. A number of large lift schemes have since been completed in Uttar Pradesh on the Ghagra and other rivers. The Ghagra Pumping Scheme lifts 17 cumecs (600 cusecs) to a height of 15 metres (49 feet) to serve a culturable commanded area of about 117,000 hectares (288,000 acres).

6.48 In Maharashtra, co-operative lift irrigation schemes are popular, and roughly 200 are in operation. These are being encouraged with loans from the State Government. Water is lifted from rivers or streams by means of diesel or electric pumps, and distributed through permanently

laid out, or portable, pipes. In some schemes, the lift is as high as 55 metres (180 feet). The Government charges a royalty of Rs. 100 per hectare of sugarcane irrigated by the co-operatives. For other crops, the rates are lower, as they use less water. These lift schemes are a success.

6.49 Floating pumping schemes are in use in many countries. They have a number of advantages. They leave the river regime undisturbed and do not submerge any land. There is, therefore, no unwholesome rise in the ground water table, as in the case of ponds upstream of a barrage. The floating pumps operate under a constant suction-head and consequently a cheaper fixed-blade type propeller, of high efficiency, can be designed for centrifugal pumps. Another advantage is that water is sucked from just below the water surface, where the silt content is low. Unlike fixed pumping stations, the floating pumps do not require expensive foundations, because they are mounted on relatively cheap barges. Nor do they require elaborate bank-protection works. Floating pumping schemes can be executed quickly. Some sizable floating pumping schemes in Uttar Pradesh have taken less than a year to complete.

6.50 In recent years, a number of floating pumping schemes of various sizes have been erected in the country. In Orissa there are a number of barge-mounted, electrically-operated pumps, with a discharge capacity of about 0.08 cumec (3 cusecs) each. An electric line running along the river bank provides the power for the pumps. The barges are moved up and down the stream to irrigate fields along the bank. In Uttar Pradesh, the failure of the monsoon in 1966 led to the sanction of a scheme for the installation of 1,000 diesel pumping sets of 5 to 10 h.p., mounted on barges, as an emergency measure, to pump water from different rivers to provide instant relief to adjoining areas. The diesel schemes, their high operational cost notwithstanding, were quite successful. There was a demand for their permanent retention, and the electrification of these lift pumps was taken up shortly thereafter.

6.51 The State, thereafter, undertook a number of larger floating pumping schemes. The first one was completed in 1967 on the Ganga in Mirzapur district, to feed 1.4 cumecs (50 cusecs) into the tail-reaches of the Left Khajuri Canal System. It was followed, in 1969, by the Dalmau Pumping Scheme in district Rae Bareili, the Zamania Pump Canal in district Ghazipur, and the Bhopauli Pump Canal in district Varanasi, with 11.9, 10.2 and 10.2 cumecs (425, 360 and 360 cusecs) capacity, respectively. These river pumping schemes are useful in situations where river water cannot be tapped economically through a barrage, and where considerable water flows in the river throughout the year.

6.52 We are of the opinion that major rivers. particularly the Ganga and the Brahmaputra, which flow through alluvial plains. offer considerable scope for floating pump-irrigation schemes. On these rivers. pumping in moderate capacities can be done economically at a number of convenient places. We. therefore. recommend that it would be worthwhile to explore possibilities of floating pump schemes in Assam. Bihar. Uttar Pradesh and West Bengal. and on some major rivers in other States.

Utilisation of Flows of Lower Dependability

6.53 The rainfall in various catchment areas varies from year to year. and so does the volume of water in rivers. Irrigation projects have to be so designed that their full requirements are met in most years. At present, the practice is to design the projects to utilise river flows of 75 per cent dependability. It means that in 75 years there is some surplus in the river. and in 25 years some shortage. ranging from marginal to substantial. It is obvious that the higher the dependability. the less the quantity of water available for utilisation. Availability can. however. be improved by providing an extra capacity in the reservoir for carrying over supplies from surplus years to lean years. By adopting this device. a project can be designed on river flows of lower dependability to provide a larger volume of water to irrigators. with the same degree of assurance. But the provision of carry-over capacity in a reservoir entails additional cost. and it becomes a matter of evaluating the additional supply against the additional cost. The more precious the water in an area. as in drought areas. the greater is the justification for providing a carry-over. We have dealt with the policies regarding irrigation in drought affected areas in Chapter VIII.

6.54 We consider that the farmer should be assured of getting the designed supply in 75 per cent of the years, and the existing practice of planning irrigation schemes on the basis of 75 per cent dependability should continue. Where a carry-over is provided, the 75 per cent dependability can be figured out, taking into account the carry-over water.

6.55 As variations in the year to year supply are inherent in all major irrigation schemes, we suggest that, well before the rabi season. the farmer should be informed of the quantity of water likely to be available from a reservoir. so that he may adjust his cropping suitably. The information in respect of run-of-the-river schemes would be less definite. but even a broad indication would be helpful.

Resources other then Surface and Groundwater

6.56 Surface and ground water are the main sources of irrigation. Artificial rain-making and the use of desalinated water are the other possibilities which we have examined. though no actual use has yet been made of them in this country.

Artificial Rain-making

6.57 Experiments made in the forties' in artificial rain-making evoked a good deal of public interest in many countries. raised high expectations. and often led to exaggerated claims of achievement. In 1946. the first man-made snow storm was created by dropping dry-ice (solid carbon dioxide) pellets from a plane flying above super-cooled clouds over Pittsburg in the U.S.A. Since then. more than 50 nations have been conducting experiments in local weather modification by cloud seeding. In India. cloud seeding experiments have been carried out since 1952 at Coimbatore and Ootacamund. and later at some other places. A Rain and Cloud Research Unit was set up in 1953 at the National Physical Laboratory.

A pre-condition for artificial rain-making is the presence of clouds of a suitable type and adequate depth. which enables the rain-maker to assist the growth of minute cloud-water particles to raindrop size. The process consists in injecting into the cloud the nuclei of substances like silver iodide or sodium chloride. which in a supercooled cloud. lead to the creation of ice crystals and may result in snowfall. and in the case of warm clouds help in the formation of rain-drops resulting in rainfall. The time between cloud seeding and the first appearance of rain may vary from 5 to 50 minutes depending upon the state. size and height of the rain bearing cloud. Only cumuliform clouds are suitable for seeding. These generally have to be more than a thousand metres in depth for successful operations. Precipitation may not fall to the ground if the intervening air is too dry and the rain drops re-evaporate.

There are many factors which influence the ultimate result of rain-making. Clouds of suitable type and size cannot be made to appear whenever and wherever one wants them. However. in certain localities it often happens that during dry spells in the rainy season. there is much convective cloud cover. but little or no rain. Occasions like these may prove suitable for rain-making. and be of considerable benefit. particularly if the period happens to coincide with an important stage in plant growth. Such climatic features often occur over parts of Bihar. Gujarat and south Rajasthan during the south-west monsoon and parts of Tamil Nadu and Andhra Pradesh during the north-east monsoon.

Artificial rain-making can prove useful in increasing the water yield of catchments of large river valley projects. by milking clouds which otherwise would not precipitate. With the present state of our knowledge of the subject. however. we are of the view that in our planning for the development of water sources. it is premature to count on artificial rain-making as a measure for augmenting water supplies. However. we recommend that research on artificial rain-making should be carried out on a wide scale. in areas where it holds promise.

Use of Desalinated Water

6.58 There are several processes for desalination. such as evaporation. freezing. and electrodialysis through membranes. These processes have several variants. The first land-based commercial desalination units were built more than forty-five years ago. There are now over a hundred such plants in operation, mostly around the Mediterranean, the Persian Gulf and the Caribbean. Kuwait has one of the largest plants. India has none as yet.

Desalinated water is expensive. The desalination process in Kuwait. which is among the cheapest. has been reported to cost $ 0.39 (about Rs. 2.9) per cubic metre.* A few years ago consideration was given to the possible erection of a combined water and power installation at Madras. to meet the growing water demand there. Preliminary cost estimates were reported to be of the order of rupees three per 1000 gallons. In areas of acute water shortage. there can be economic and social justifications for the use of such high-cost water for industrial and domestic use. but hardly any for its use for irrigation. With advances in technology. however. it is conceivable that. at some future date. desalinated water may be used. in special cases. for the supplementary irrigation of high-value crops.

Resettlement and Rehabilitation of Displaced Persons from River Valley Projects

6.59 The construction of large reservoirs poses a difficult and complex problem of rehabilitating oustees from the reservoir area. The construction of large canals. like the Rajasthan Feeder. also poses a similar problem. It has to be recognised that these persons are displaced so that others may benefit from the project. Their problem should. therefore, be dealt with as a human problem, with the utmost sympathy. It should invariably receive high priority.

*Water Desalination in Developing Countries—U.N., 1964.

On several projects like Bhakra Nangal, Hirakud, Rihand etc., attempts were made to compensate the displaced persons with new land allotments. New habitations with improved amenities were set up, but these measures met with only partial success. For instance, at the Hirakud Project, some forest land was reclaimed and made fit for cultivation and new houses were built for the displaced persons. But the cost of cultivation on this reclaimed land was higher than in established villages, and before long they were abandoned and the forest reappeared.

6.60 Man, like fauna and flora, becomes a part of his environment and it is no surprise that persons displaced by a project do not desire to trek far away from the place of their original habitation. The construction of an irrigation project invariably leads to a spectacular rise in land values. We see no reason why the displaced persons should not share the new prosperity. These people should have a right to live in the commanded area of the project and we recommend that part of the larger holdings in that area should be acquired for settling them. If there are government wastelands available, these should be developed and allotted to them. This may not always be feasible, as for example in the hills. In such cases oustees who are willing to shift should be given land for land in the lower reaches of the canal. There may be cases where the canal passes through uninhabited or thinly inhabited areas with promising irrigation possibilities. We suggest that new villages should be developed in these areas as was done in the case of the Punjab canal colonies. Oustees from the same village, including non-agriculturists, should be shifted to a new village so that they can recreate the life of the whole village. What was done for the Punjab colonies is described in paragraph 7.3 of Chapter VII. We would not, however, recommend the denudation of forests, which are already below the limit prescribed under the National Forest Policy. Loans, and other facilities such as the supply of building material, should be given to them on a priority basis. They should be accorded preference in employment on the construction works, and non-agricultural oustees should be given commercial premises, and facilities for training in polytechnics. It is obvious that no hard and fast programme can be laid out but the governing factors in rehabilitation should be humane.

Classification of Works

6.61 In the latter part of the nineteenth century irrigation works were classified according to the mode of financing. They were divided into two main classes : those whose construction was wholly or mainly financed from loans; and those in which the cost was charged to the

general revenues. The former were called 'productive' and the latter 'minor'. Some time after the establishment of the Famine Fund, an intermediate class called 'protective works', was created. Thus at the time of the setting up of the First Irrigation Commission in 1901, there were three main classes of irrigation works viz.,

(a) Productive Works—capital outlay of which was sanctioned against loan funds in the expectation that the works would prove directly remunerative.

(b) Protective Works—which were not considered likely to fulfil the conditions of 'Productive Works' but which had to be sanctioned against the Famine Fund because of their protective value.

(c) Minor Works—outlay on which had to be met from general revenues. This included all works which were not classed as Productive or Protective.

6.62 The First Irrigation Commission proposed a simplification in the classification of irrigation works, which it thought would be more consistent, rational and intelligible to non-experts in irrigation finance. The Commission's proposals were as follows :

(i) Major works; to include all works for which reliable capital and revenue accounts were kept, whether the capital cost was met from loan funds or from the famine grant or from current revenues.

(ii) Minor works; to include all works for which capital accounts were not kept. These were sub-classified into

(a) Minor works for which revenue accounts were kept, and

(b) Minor works for which revenue accounts were not kept.

Thus, the new classification of irrigation works was based on the mode of financing and on the requirements of account-keeping. In course of time, the three classes of irrigation projects viz., Productive, Unproductive and Minor came to be recognised as below :—

(a) A Productive Work was one, the net revenue derived from which, within ten years after date of its completion, was more than the prescribed percentage on the sum-at-charge. The sum-at-charge included direct charges such as the cost of works, land and establishment, and also indirect charges and all arrears of simple interest on the capital outlay, if any.

(b) Unproductive Works were those which yielded a net revenue less than the prescribed percentage, fixed from time to time, for Productive Works.

(c) Minor Works were small works for which detailed capital and revenue accounts were not maintained. These works could be productive or unproductive.

6.63 After Independence the concept of financing irrigation projects underwent a radical change, although the principle of Productive and Unproductive projects continued in force. All new irrigation schemes were to form part of the development programme under the Plans, and had to be financed out of Plan funds. In the First Five Year Plan, the irrigation schemes were broadly classified as major and minor, the minor ones representing schemes costing less than Rs. 1 million each.

6.64 Private Irrigation works, though they account for nearly one-half of the irrigated area of the country, are relatively small in size, and do not ordinarily involve complex engineering problems. They comprise wells, private tubewells, small irrigation tanks, small canals and devices for individual lifting or pumping of water from rivers, nallahs, drains etc. Government exercises little administrative control over these schemes, but gives financial assistance, in the form of loans and grants, for digging new wells or repairing old ones, and for establishing new pumps. This financial assistance forms part of the outlay for minor irrigation in the Plans.

6.65 During the course of the First Five Year Plan, the irrigation programme was expanded to include improvements to medium size irrigation schemes in scarcity areas. In the Second Plan, 195 new irrigation projects were included; of these, 17 cost more than Rs. 50 million each, and the remaining 178 less than Rs. 50 million. The latter were classified as Medium Irrigation Schemes. Thus we had three classes of irrigation projects viz., Major, Medium and Minor.

6.66 The classification of old irrigation schemes, posed certain difficulties. The application of the financial yardstick to schemes constructed long ago was not found practicable, on account of the change in prices. In some cases, the cost figures were not even available. In 1959 it was decided that pre-Plan schemes irrigating up to 1600 hectares should be regarded as Minor Schemes. The financial ceiling of Rs. 1 million for individual Minor irrigation scheme was later raised to Rs. 1.5 million and has further been revised upward, from April 1, 1970, to Rs. 2.5 million in the plains and to Rs. 3 million in hill areas.

6.67 The classification of schemes as Major, Medium and Minor is now a well-established concept in our Plans, and may continue both for statistical and administrative purposes. The policy of classifying irrigation works on the basis of capital investment does not, however, appear to us to be rational. With the continuous rise in prices, a work which, at the time of sanction, was classified as Medium, may become

Major by the time it is completed. Moreover the parity between works built at different times is being continuously disturbed by the change in prices. We are of the opinion that a physical criterion for classifying Minor irrigation schemes would be more rational. We recommend, therefore, that Minor irrigation schemes should comprise the following :

(a) All ground water schemes, whether they consist of open wells, deep or shallow tubewells or filter-points. However, where a battery of tubewells is set up to supplement water of an existing canal, or to feed a new canal, the scheme should be classified as Major, or Medium, depending on its size.

(b) Surface water schemes which envisage a net irrigation of not more than 1600 hectares, whether they consist of small irrigation tanks, small canals taking off from small streams in hills or plains, or individual lifting or pumping schemes from rivers, nallahs or drains. The limit of 1600 hectares had already been prescribed for Minor irrigation works in classifying pre-Plan schemes, and the same may as well be adopted for Plan Schemes. The physical norm for classifying Minor schemes will not be affected by changing prices.

6.68 There were two main reasons for the creation of the 'minor irrigation' category in the classification of irrigation schemes. The first was administrative and the second the nature of the works, most of the schemes being for the exploitation of ground water. These considerations did not apply to Major and Medium schemes, and the distinction laid down for them was quite arbitrary. The dividing line could as well have been Rs. 100 million, instead of Rs. 50 million. Also surface water development schemes, even though not large, can confer other benefits besides irrigation. Classification of Medium schemes on the basis of area irrigated may not, therefore, reflect the real size of a scheme. As the distinction between Major and Medium schemes is in any case arbitrary, there will be no particular advantage in changing the existing monetary yardstick for classifying these schemes.

CHAPTER VII

AYACUT DEVELOPMENT

Early Attempts

Systematic ayacut development in India has taken shape only recently. Its aim is to ensure rapid utilisation of the irrigation potential of new irrigation projects. This calls for a series of co-ordinated measures. The command areas of projects should be fixed in advance. Soil surveys should be undertaken, and only those crops which are suited to local soil and climatic conditions should be encouraged. Scattered holdings should be consolidated. Farmers' fields should be properly levelled, shaped and kept ready with field channels, so that the water can be utilised without delay, as soon as canals and their distributaries are completed. The supply of inputs needs to be streamlined, and research and extension efforts geared to support a forward-looking agriculture. Attention should also be paid to the need for additional roads, markets and storage and other infrastructure facilities.

7.2 Apart from the canal colonies in Punjab, irrigation projects constructed during British rule were designed to strengthen settled agriculture, i.e., protect kharif crops against the failure of rains and permit, wherever possible, the raising of a rabi crop. Their command areas were mostly level and required little by way of land-shaping or terracing. The Western and Eastern Yamuna Canals, the Upper and Lower Ganga Canals, the Agra Canal and the Sarda Canal of north India, and the Godavari, Krishna and Cauvery systems of the south conformed to this pattern. After the completion of an irrigation work, the State's responsibility was limited to the maintenance and upkeep of headworks, canals and distributaries, the supply and distribution of water at the outlet, and the assessment and collection of water rates. No steps such as setting up of demonstration farms were taken to help the farmer to switch over from dry cropping to irrigated farming, not even in the famous Montgomery and Lyallpur colonies.

7.3 The canal colonies had been developed in Punjab on semi-arid

and uninhabited wastelands lying between the Jhelum, Chenab, Ravi and Sutlej rivers, by diverting their perennial waters, through numerous canals—Sidhnai, Lower Sohag, Lower Chenab, Lower Jhelum and the Triple System consisting of the Upper Chenab, Lower Bari Doab and Upper Jhelum Canals. Before work on any of these canals was started, its command area was carefully surveyed and divided into large-sized squares or rectangles, which determined the approximate alignment of the main canal and its branches. These blocks were then divided into smaller blocks* which set the pattern for the layout of distributaries and water courses and for allotment to farmers. The most efficient alignment could thus be followed while planning the entire canal system, without interference of any kind. This procedure also enabled the demarcation of clusters of compact allotment units. Each cluster which later emerged as a village was commanded by one or more water courses. Once the village sites were settled, house-sites, main streets, sites for community works etc. were laid after the traditional pattern of the Punjab village. When the colonist arrived, a house-site and one or two squares, or allotment units, were given to him, so that he could start the construction of his house and field channels straightaway. The selection of colonists from various parts of the Punjab was done after careful scrutiny. Large farmers, indebted farmers and farmers physically unfit or socially undesirable were excluded, and only enterprising ones with skill and resources were chosen. They were moved in groups, farmers coming from the same village being settled together in one new village. Community life was soon resurrected in the new settlements. The virgin lands produced rich crops of wheat and cotton. For the disposal of surplus produce, *mandis* (markets) were set up. The Government opened up the area by constructing roads and railways for the transport of wheat and cotton. The development of canal colonies in Punjab is a saga of the co-ordinated efforts of an enterprising peasantry, and imaginative Governmental action.

7.4 The canal colonies are in many respects forebears of the new ayacut development programme. The colonist no doubt had to mobilise his resources—financial and material; he might also have had to borrow money at exorbitant rates of interest from the money-lender who accompanied him from the home village, but the planning of fields and villages and the ready-made alignment of field channels helped him substantially. The development of the infrastructure, in particular the construction of roads and railways, without which the surplus produce could not

*These blocks measured 22.5 acres in the Sidhnai Canal Colony, 25 acres in Triple Canal Colonies and 27.8 acres in Sohag, Lower Chenab and Lower Jhelum Canal Colonies.

have been marketed, are features that the canal colonies and the ayacut development programmes share in common, together with the spirit of co-operation between official agencies and the farmer.

Problems of Ayacut Development

7.5 Some of the irrigation projects built since 1947, especially those in the south, such as Tungabhadra and Nagarjunasagar, differ radically from those constructed earlier. Unlike the projects on the perennial rivers fed by the Himalayan snows, these projects have to impound monsoon flows in expensive reservoirs, for use during the drier parts of the year. The ayacuts of these projects are undulating and their preparation for irrigated agriculture requires considerable labour. Scanty population, inadequate cattle power, traditional methods of cultivation and lack of resources are only some of the difficulties faced. Problems of localisation, water-soil management and the advent of high-yielding and hybrid crop varieties demanding heavier inputs, add new dimensions to the problem.

7.6 The Tungabhadra, the first major irrigation project of the post-Independence period was completed in the fifties and it was in the ayacut of this project that the concept of light irrigation, i.e., spreading the benefit of irrigation to larger areas, was deliberately introduced. In this system, a small part of the command area is reserved for a wet crop like rice and for perennial crops like sugarcane, and the remainder for light irrigated crops like jowar, bajra, cotton and groundnut. Because of the large difference in the water requirements of wet and dry crops, against every 20 hectares of irrigated paddy the command could provide water for 65 hectares of light irrigated crops like jowar and bajra. This made it possible to bring a much larger area under irrigation.

7.7 Although the State arranged several field demonstrations, many farmers remained reluctant to switch over from dry farming to light irrigation. This led to delays in the utilisation of the irrigation potential created by the Tungabhadra Project. Analyses have shown that the major obstacles were the heavy cost involved and inadequate facilities for land levelling and land shaping. Sufficient credit, cattlepower and machinery, too, were not available. There was also lack of co-operation between farmers in constructing field channels and taking water to the fields. Co-ordination between different departments and agencies engaged in the development of the ayacut was not effective.

7.8 The Tungabhadra system was not the only example of its kind.

Progress was equally slow in the case of the Kosi, Chambal and Hirakud Projects. The Commission has been informed by the Maharashtra Government that in the command areas of new projects with a rainfall of about 700 mm. there is marked reluctance among farmers to use irrigation in kharif season. This adversely affects the utilisation of the water potential of these projects in the kharif season. Where the rainfall in the rabi season ranges between 150 to 250 mm. utilisation of irrigation also suffers for the same reason.

7.9 As a result of this inability or indifference on the part of farmers there is a sizeable gap between the irrigation potential that has been created and its utilisation. During the decade 1950–51 to 1960–61, an additional irrigation potential of 4.7 million hectares was created under major and medium schemes, but actual utilisation was only 3.4 million hectares, leaving a gap of 1.3 million hectares. In the next eight years, that is, between 1960–61 and 1968–69, an additional potential of 4.1 million hectares was created, but out of the accumulated potential of 8.8 million hectares at the end of the period, the unutilised potential was 1.6 million hectares.

7.10 At present, estimates of irrigation projects do not make any provision for the cost of developing the ayacut. They do not set apart funds for research or the training of farmers in irrigation practices. Nor is any provision made for the development of the infrastructure facilities like roads, transport and communications, markets, storages and warehouses. This results in delays in the utilisation of irrigation water. The Commission recommends that a comprehensive plan of ayacut development should be prepared for every major and medium irrigation project. This plan should be worked out along with the investigation of engineering works and separate financial provisions made for the two.

Administration and Co-ordination

7.11 Ayacut development is an exceedingly complicated task, requiring a high degree of organisational and administrative co-ordination between services handled by different government departments and institutions. The Irrigation Department no doubt provides the water, but teaching the farmer how to make prompt and efficient use of it is a task for the technical and extension services of the State's Agriculture Department. Broadly, a programme of ayacut development calls for the assistance of the State's Departments of Irrigation, Agriculture, Animal

Husbandry, Co-operation, Community Development, Finance and Public Works, and various institutions such as the Central and State Warehousing Corporations, the Agricultural Refinance Corporation, Land Mortgage/Development Banks and the nationalised and private Banks although the prime responsibility would rest on the Agricultural Department. It may even make new demands on the Posts, Telegraph and Telephone services of the Centre and the Health and Education Departments of the State. In brief, ayacut development calls for all the services that are needed to build a newer and higher social order.

7.12 The Commission is of the opinion that a special administrative agency for the co-ordinated and expeditious development of command areas under medium and major projects has become a necessity. Whatever be the nature of the agency, it should exist only for the period during which speedy action is needed, and as soon as the ayacut is fully developed the agency should be abolished. It follows that no separate cadres should be created for the ayacut development programme and that relevant departments of the State Government, such as Irrigation, Agriculture, Co-operation, etc. should continue to discharge their respective functions within the ayacut under the normal departmental control. The co-ordinating agency for the ayacut could, however, set out specific jobs for various departments and institutions, co-ordinate their activities and ensure implementation of the agreed programme.

7.13 The Mysore Government has designated the Divisional Commissioner of Gulbarga as Administrator for the ayacut of the Tungabhadra Project, for both Raichur and Bellary districts. He functions as the Chairman of (i) the Working Group consisting of officers connected with the Tungabhadra Project; (ii) the Advisory Board consisting of officers, M.L.As. and representatives of ayacutdars; and (iii) the Consultative Committee of ayacutdars' representatives and officers. The function of the Administrator is to co-ordinate and accelerate the development of the ayacut. The Deputy Commissioner of Raichur has been designated as the Director, Tungabhadra Project Left Bank Canal, and made responsible for co-ordinating the activities of various departments in his district. He is also responsible for executing land-levelling works under the Agricultural Refinance Corporation's scheme. Likewise the Deputy Commissioner of Bellary has been appointed Director of the Right Bank High Level & Low Level Canals. The Joint Director of Agriculture and the Joint Registrar of Co-operative Societies have both been put incharge of the whole ayacut to promote their departmental activities. The arrangement has, on the whole, worked satisfactorily and has speeded up the pace of ayacut development.

7.14 In Andhra Pradesh a Member of the Board of Revenue has been designated as Ayacut Development Commissioner to co-ordinate the activities of several departments. Under his chairmanship the Government has also constituted a 'State level Committee for Development of the Nagarjunasagar Ayacut', to facilitate the allocation of specific tasks to departments concerned with its development and to secure their co-operation in implementing an agreed programme. The Committee consists of the concerned Secretaries to Government and Heads of Departments, the Collectors and the Chairmen of the Zila Parishads of the districts concerned and the President of the Andhra Pradesh Co-operative Central Land Mortgage Bank. There is also a provision to notify as members any other officials or non-officials connected with ayacut development. The Collectors of Nalgonda and Guntur have been associated with the formulation and execution of ayacut development schemes, and district-level committees have been constituted for the districts with the Collectors as Chairmen. A Joint Director of Agriculture has been specially posted for the programme at the State level. The system has worked well and has resulted in some development of the ayacut even in the first year of letting out water.

7.15 The Government of Bihar has appointed a whole-time officer as the Kosi Area Development Commissioner, who has also been notified as the Additional Commissioner of the two districts of Purnea and Saharsa, in which the Kosi command lies. The arrangement had to be made because Purnea and Saharsa districts are parts of different Revenue Divisions. In each of the districts, there is an Area Development Committee presided over by the Development Commissioner. District Collectors have been put incharge of the Intensive Agricultural Development Programme in their respective districts and they are assisted by subject matter specialists of various departments. The main functions of the Development Commissioner are planning and co-ordination, general direction and supervision. For the whole State, an Advisory Committee has been set up with the State Development Commissioner as the Chairman and the Kosi Area Development Commissioner as the Secretary. Representatives of relevant departments are members of the Committee. The arrangement has provided an agency for a co-ordinated action programme. However, we note with concern that after seven years of the opening of the canal, the irrigation in kharif 1970–71 was 0.12 million hectares against 0.32 million hectares envisaged in the Project Report. There may be factors responsible for this slow development other than the functioning of the Area Development Organisation. We suggest that this matter should be examined.

7.16 The Commission is of the opinion that the larger irrigation ayacuts are sufficiently important to merit a separate development agency. Its functions should be to assign tasks to various departments and institutional agencies, to enforce co-ordination among them, and to see that the agreed programme is implemented. The Commission recommends that separate development agencies may be set up for irrigation projects with extensive command areas.

7.17 The actual composition of these bodies will depend upon the administrative set-up of the State and the socio-economic conditions of the area. The Commission has, therefore, not attempted to lay down any specific pattern for the composition of coordinating bodies. What matters is that they should be able to enforce effective coordination at all levels—State, project, district and lower down. Representatives of various departments and institutional agencies connected with development work should be effectively represented on these co-ordinating bodies. Two progressive farmers of the ayacut should also be nominated. For larger projects the co-ordinating organisation must be headed by a senior official of the status of a Member of the Board of Revenue or a Divisional Commissioner. He may be whole-time or part-time according to the volume of work involved. In case the head is a part-time officer, he should be assisted by a fairly senior whole-time officer. For other major and medium irrigation works the State Governments are advised to set up a co-ordinating agency for the whole State with the same functions. The agency may appoint an officer or set up a subordinate body for a project or group of projects. For instance, in a State like Madhya Pradesh, which has taken up a number of major irrigation projects, none of which would qualify for its own ayacut agency, separate groups may be constituted for projects like Tawa, Bargi and Bansagar. These projects are big enough to require special attention.

The State Governments should have periodical evaluations made by an independent authority of the progress of ayacut development programmes.

7.18 While touring Andhra Pradesh, the Commission was impressed by the special arrangements for co-ordination which had been made at the field level in the Nagarjunasagar Project to hasten the development of the ayacut. The State Government constituted several four-member teams, each consisting of representatives of the Revenue, Agriculture, Irrigation and Co-operative Departments, with a Block Development Officer as the convener. These teams tour the villages and advise farmers on off-take areas and the location of water courses for fields, the settlement of water disputes, cropping patterns and the cultivation of improved

varieties of crops. They also assist ayacutdars in obtaining loans from the Land Mortgage Banks, and inputs, like seeds, fertilizers, pesticides, etc. Through their efforts, they were able to remove many of the bottlenecks in the supply, regulation and distribution of water to the fields. The Commission recommends that in all new projects such teams should be constituted in the initial stages of development for solving the problems of farmers on the spot and helping in the expeditious development of the ayacut.

Extension Services—Staffing Pattern

7.19 The National Extension Service provides a uniform staffing pattern throughout the country irrespective of the nature of farming and the volume of work involved. This may be adequate for traditional agriculture, but the requirements of irrigated agriculture are more exacting and call for more frequent contacts between the extension staff and farmers at different stages of plant growth. The extension worker is needed not only to tell the farmer what can be done but also to teach him how it can be done. There is, therefore, a need to strengthen the staffing pattern at different levels. The field staff will also need expert guidance in various subjects such as agronomy, plant protection, water management, etc. This guidance can be provided by duly qualified subject-matter specialists, who would keep in constant touch with the research stations, both in the command area and outside, and pass on the latest findings of research to field workers.

7.20 In the Intensive Agricultural District Programme (IADP), additional staff has been provided at all levels to meet the increased load of work under irrigated agriculture and this has produced satisfactory results. Development work in newly irrigated areas is more exacting than in a partially developed IADP district. The Commission does not desire to lay down any hard and fast rule regarding the staffing pattern for such areas as the size of the additional staff requirement will have to be determined by local conditions and the amount of work involved. The Commission, therefore, recommends that the State Governments should give due consideration to the employment of additional staff at different levels, to attend to the development of the command area and cultivation of crops under irrigation. The Commission also recommends that there should be qualified and competent subject-matter specialists to guide the field staff on different aspects of irrigated agriculture including water use and management.

Pre-Irrigation Surveys and Localisation

7.21 The determination of the command area of irrigation projects in north India is based on the availability of irrigation supplies and a topographic survey. The alluvial soils of this region can grow a variety of crops according to the farmer's choice, and hence it is not necessary to prescribe any cropping pattern. In the south, however, red and black soils of different depths, texture and structure occur. These soils respond differently to heavy and light irrigation and vary in their suitability for different crops. Reconnaissance soil surveys and detailed pre-irrigation soil surveys are, therefore, necessary in these areas to determine the command, demarcate irrigable and non-irrigable areas and indicate the crops to be grown. Soil survey data would also serve as a guide in designing distribution channels and drainage systems to prevent waterlogging and salinity.

7.22 Irrigation works in drought areas are meant to provide insurance against famine and scarcity. It follows that the benefits of irrigation must cover as wide an area as possible. This can be ensured only if the area under perennial crops like sugarcane and a wet crop like rice, is limited, and light irrigated crops are encouraged. Prior to the Tungabhadra Project, irrigation under the canal systems of the South consisted mostly of intensive irrigation facilities for rice and other heavy water consuming crops like sugarcane. In the Tungabhadra Project, however, light irrigation i.e. supplemental irrigation for rainfed crops like jowar, ground-nut, cotton etc. was introduced in specified portions of the ayacut. This concept of distributing available water to as large an area as possible, with the specific objective of mitigating the scarcity and drought conditions in the command was also extended to all the later projects like Nagarjunasagar, Pochampad, Parambikulam Aliyar etc. Mysore State has gone even a step further and has prohibited the cultivation of rice and perennial crops in the Malaprabha and Ghataprabha projects.

7.23 In determining localisation in the case of the Tungabhadra Project it was feared that a crop like paddy, grown on black soils, would lead to waterlogging and salinity. Black soils were thus generally localised for light irrigation, both in the kharif and rabi seasons, and red soils for heavy irrigation, i.e., rice. However red soils situated at higher levels, when planted with paddy, gave rise to seepage which affected the black soil area lower down, so that the cultivation of light irrigated crops on these soils became difficult. The Commission, therefore, feels that in addition to soil classification, topography should also be taken

into consideration for localising heavy and light irrigated crops. Wherever faulty demarcation has led to waterlogging and salinity, re-localisation should be undertaken.

7.24 In Mysore State more than 80 per cent of the area under major and medium projects has been localised for light irrigated crops. The Commission has observed during its tour that areas localised for paddy and sugarcane have developed in full, whereas irrigators still hesitate to grow light irrigated traditional crops because of their low profitability. Since groundnut offered a profitable crop in red soil areas localised for light irrigation, these tracts, too, had made good progress, leaving the black soil areas lagging behind. The Mysore Government has informed the Commission that with better enforcement of the cropping pattern and the availability of hybrid varieties of light irrigated crops, the position has improved lately. The introduction of Mexican wheat and a new strain of cotton called HAMPI, has made a real difference to rabi cultivation in black soil areas. Thus, the problem is at present largely limited to kharif areas with black soils under light irrigation. The Commission hopes that with suitable efforts and timely supplies of water, it should be possible to grow hybrid jowar, hybrid bajra and cotton in these soils. Since the prospects of hybrid jowar cultivation in these areas depend on the availability of water in early June, this matter should receive special attention.

7.25 In irrigated areas wherever farmers have not taken to the more profitable high-yielding crops this is either because of the non-availability of inputs, including credit, or because they remain ignorant of modern agricultural practices. In paragraph 7.20 above, we have recommended the need to strengthen the extension network in newly irrigated areas. The Commission has no doubt that if the technical and economic aspects of modern farming are properly explained and demonstrated the farmer will readily take to new practices. We recommend that wherever there is a marked tendency among farmers to adhere to traditional practices, a special responsibility should be cast on the extension staff to persuade the farmers to take to modern farming. We see no reason why, with greater effort, the farmer cannot be made to grow new high-yielding varieties.

7.26 In reply to the Commission's Questionnaire the Mysore Government expressed the fear that localisation may lead to some delay in the development of the ayacut. We do not think that the fear is altogether unfounded. It has been found that where free cropping is permitted, farmers in the south invariably prefer rice. The water requirements of

rice being much higher than those of dry irrigated crops, free cropping would restrict the benefits of irrigation to a smaller number of persons, leaving out many others who, under localisation, would otherwise have benefited. This would enhance economic disparities between dry farmers and those who use irrigation. The Commission recommends that wherever a State has to make a choice between free cropping and localisation, specially in the water-scarcity areas, the choice should be in favour of localisation. Other measures, such as the introduction of high-yielding varieties of crops supported by adequate State aid, should be encouraged as instruments for expediting ayacut development.

Consolidation Operations

7.27 In para 7.4 we have noted how the pre-irrigation planning of canal colonies, with methodically aligned water courses and field channels, helped in the speedy development of agriculture in Punjab. This procedure is, however, not possible in settled areas already under cultivation. In such situations consolidation of holdings acquires a special relevance. During consolidation, the topography and drainage pattern of the area should be taken into consideration to facilitate the location of roads, channels and drains. The effort should be to ensure that each field is served by a channel and a drain. This will not only promote effective and economic use of water but also minimise drainage problems. Consolidation of holdings includes earmarking of the area required for roads, channels, drains, etc. and re-distribution of the remaining area among the holders of land in such a way as to make individual holdings more compact, and proportionately equivalent in value to the area held by individual holders previously. Consolidation will prove to be helpful in the rapid and efficient development of irrigated agriculture. The Commission, therefore, recommends to State Governments that consolidation of holdings in the ayacut should be given due importance and treated as part of the development programme.

Water Courses and Field Channels

7.28 A water course has been defined by the Planning Commission as a channel, built at Government expense, to convey water from an outlet to a 40 hectare block or as may be prescribed. The area for which a water course has to be constructed varies from State to State according to local conditions relating to topography and the cropping pattern. In 1958, the Planning Commission recommended that project authorities should be made responsible for the construction of water courses at project cost for chaks or blocks up to 40 hectares in area. Beyond this,

field channels were required to be built by cultivators to serve the various fields within the blocks. The responsibility for the maintenance of both the water courses and the field channels was to be that of the beneficiaries. It was suggested by the Planning Commission that the State Government should have the power, through legislation, to construct field channels and to maintain water courses and field channels should the beneficiaries fail to do so themselves, and to recover the cost from the latter.

7.29 In 1959, the Planning Commission further recommended that the project authorities should mark the position of outlets and also the alignment of water courses and field channels at the time of marking the alignment of distributaries and minors. The cultivators whose areas lie in the command of those outlets should be given notice to complete the construction of the field channels within a specified time. This specified time should be sufficient to give ample opportunity to the cultivators to complete the construction of the field channels before water for irrigation becomes available. The position of outlets at times has to be changed for securing better command of the area. This may become necessary in spite of detailed levelling and contour mapping carried out by the project authorities. The Planning Commission had, therefore, suggested that an assurance should be given to cultivators, that should it become necessary, at any time, to change the position of an outlet after the field channels have been constructed by them on the alignment marked out by the project authorities, any channel necessary to connect the field channel to the new location of the outlet would be constructed at project cost.

7.30 The States are unanimous that the absence of field channels has been a major factor behind the serious lag in the utilisation of irrigation potentials. During our tour of Mysore State, we learnt that the slow progress in the utilisation of the Tungabhadra potential had brought home to the State Government the importance of field channels, and in 1966 it took upon itself the responsibility of excavating them. Till then, the task had been left to the farmers. Funds amounting to about Rs. 25 million, or just 3.2 per cent of the project's total cost, were provided and brought about a spectacular improvement in the utilization of the irrigation potential. The Government of Andhra Pradesh took action on similar lines in the Nagarjunasagar project and this also had a salutary effect.

7.31 We have carefully considered as to who should be responsible for the construction and maintenance of water courses and field channels. We are of the view that, normally, the responsibility in these matters should be as indicated by the Planning Commission in their letters of 1958 and 1959, referred to above.

7.32 During the course of our tours, we observed that field channels were often damaged at points at which they were crossed by village roads or cart-tracks, resulting in wastage of water. The construction of culverts and like structures requires technical knowledge, the use of pre-fabricated units, and funds. Farmers generally do not possess the necessary expertise and, therefore, the field engineering staff should either construct the culverts or advise irrigators on how to do it themselves. The use of pre-fabricated units would expedite construction. It was brought to our notice that farmers are reluctant to put up culverts etc. at their own cost since these are expensive. We feel that if some subsidy were to be given to farmers, it would expedite the construction of culverts. We recommend, therefore, that State Governments may consider giving suitable subsidies to farmers for the construction of culverts etc. on field channels which cross roads or cart-tracks.

Land-Shaping

7.33 The cost of land-shaping constitutes the single biggest item in the total cost of ayacut development in projects with undulating terrain. When the depth of the soil is good, it can stand heavy levelling. In shallow soils the scope of land-shaping is limited. Levelling operations require implements and machinery. They need technical guidance. Land has to be first levelled to a suitable gradient. Then fields have to be laid out for one of the several irrigation methods—level bed, border strip, ridge, furrow, etc. The Mysore Government has estimated that approximately one-third of the area under the Tungabhadra Project can be levelled with the farmer's own labour and bullocks; another third of the area, with a steep gradient, would need tractors, bull-dozers and other machinery made available by Government; and the remaining third could be levelled by tractors or machinery owned either by individual farmers or co-operative societies. The average per hectare cost of land levelling has been taken to vary between Rs. 568 to Rs. 1,063, in the Tungabhadra area in Mysore, and Rs. 741 to Rs. 1,446 in the Nagarjunasagar ayacut in Andhra Pradesh, depending upon the slope of the land. For the latter area, the Reserve Bank has assumed that 50 per cent of the farmers of the area would have their own resources for land-shaping and the other 50 per cent would need financial assistance through co-operatives or other institutions. In practice the credit requirements have been found to be much lower. For this reason, the original estimates for the Nagarjunasagar ayacut's first credit scheme have been reduced by 25 per cent. For the subsequent schemes it has been assumed that ayacutdars owning 40 per cent of the wet land, and 25 per cent of the dry land would need credit.

In Tamil Nadu, land-shaping is being taken up as a regular soil conservation scheme, except in the Parambikulam Aliyar Project, where loans for the purpose are advanced by the Land Mortgage Bank. The extent of the area needing financial and other assistance varies from project to project, and the Commission would not like to hazard a guess. The Commission recommends that after a thorough investigation, adequate arrangements for financial assistance should be made for land-shaping. The loan advanced should, by law, be made a first charge on the land benefited and no farmer should be refused credit for the purpose on the ground that he lacks credit worthiness.

7.34 Loans for the preparation of land are at present provided by Land Mortgage Development Banks. Such loans for big schemes involving sizeable outlays are refinanced by the Agricultural Refinance Corporation. Since its inception in 1963, 458 schemes were sanctioned by the Corporation up to 30th June, 1971, involving a total outlay of Rs. 2,930 million, of which the Corporation's financial assistance amounted to Rs. 2,486.6 million. Out of these, 43 schemes were for the development of land costing Rs. 567.2 million; the Corporation's contribution being Rs. 434.2 million. One of these schemes relates to the development of 80,936 hectares of land at a cost of Rs. 55.9 million in the Raichur district served by the Tungabhadra Left Bank Canal. The scheme is to be completed over a period of seven years commencing from 1966–67.

7.35 The Agricultural Refinance Corporation has also extended assistance to the development of the Nagarjunasagar command through a phased programme drawn up by the Central Land Mortgage Bank, Hyderabad. The first phase envisages the development of 78,508 hectares of land at a cost of Rs. 62.1 million, out of which the assistance provided by the Corporation will be Rs. 55.9 million. Additional areas are proposed to be covered in the second, third and fourth phases. Similar assistance has also been extended for land development in the Kadam and Kurnool-Cuddapah Canal Projects in Andhra Pradesh, the Kosi Project in Bihar, Kakarapar in Gujarat, Chambal in Madhya Pradesh and Rajasthan, and Parambikulam Aliyar in Tamil Nadu.

7.36 Refinancing by the Agricultural Refinance Corporation to Central Land Mortgage Banks takes the form of subscribing to 75 per cent of the debentures floated by them, the balance to be contributed by the State Government. In some special cases the Corporation contributes up to 90 per cent of debentures. The Agricultural Finance Corporation set up in 1968 by Commercial Banks also makes available some funds for agricultural development.

7.37 In addition, special taccavi assistance is given by State Governments for land development. For instance the Mysore Government has advanced Rs. 4 million as taccavi for land operations in the Tungabhadra project area. The Commission considers the institutional arrangements for refinancing and the supply of credit for levelling land to be adequate and trusts that sufficient funds would be forthcoming from the State Governments and the Agricultural Refinance Corporation.

7.38 After considerable thought the Commission has reached the conclusion that cooperatives and associations of farmers owning an adequate number of tractors can give effective help in the process of land shaping and land levelling. These societies would require advances of money from financial institutions for the purchase of tractors. The Commission saw the working of two Tractor Cooperative Societies in the Manvi taluk of Raichur district. They have been doing land levelling operations with low horse-power tractors, as heavy tractors were not available. We were told that the societies were working on a no-profit-no-loss basis and had levelled 18,211 hectares of land in two years. We are of the opinion that the effort to organise cooperative societies and associations of the farmers is worthwhile.

7.39 The Commission recommends that :

(i) adequate arrangements be made to make available machinery for land levelling operations including light and heavy tractors and bull-dozers;

(ii) cooperative societies and associations of farmers be organised by State Governments. The Manvi pattern may be examined in this connection; and

(iii) Government departments or their agencies should make direct arrangements for the levelling of steep land on a custom basis.

7.40 In view of the high cost of land-shaping for bed irrigation, it would be worthwhile to experiment with alternative methods of irrigation. In Mysore State an area of 5,666 hectares on the Low Level and High Level Right Bank Canals and 11,736 hectares on the Left Bank Canal of the Tungabhadra Project have been developed for border-strip irrigation. This method consists of dividing the field into a number of parallel border strips separated by low ridges. Water turned into the upper reach of each border strip moves down the strip in a thin sheet, guided by the ridges. The gradient in the strip usually ranges between 0.1 to 0.6 per cent, and in no case does it exceed 1.0 per cent. The method permits rapid and relatively easy irrigation. It is economical in the use of water, and requires less land-shaping than the orthodox

method of level beds. Sprinkler irrigation is also considered suitable for areas which need costly land levelling and shaping. But its adoption must necessarily depend upon the relative economics of the two systems, which will therefore need to be studied in each case before a decision is taken.

Research, Demonstration and Farmers' Training

7.41 *Research :* During its visit to the Nagarjunasagar Project the Commission found that two Research Stations had been set up in the ayacut, one for black soils at Amaravati, and the other for red soils at Garikapadu. These stations had been set up in 1963, four years before irrigation water was available. Research work in these stations was taken up in advance, and their irrigation requirements had to be met by pumping water from the river Krishna and its tributary the Palleru. When the canal water arrived in August, 1967, there was ready at hand, a knowledge of the new crop technology and irrigation practices.

7.42 Irrigation practices for different crops, specially their high-yielding varieties, vary according to the habit of the crop, climatic conditions and the nature, texture and depth of the soil. These factors vary from place to place. Thus, every major and medium irrigation ayacut needs a research programme to develop suitable cropping patterns and manurial and agronomic practices. Other factors which call for attention are, the consumptive use of water for crops, the analysis of water losses, the movement of water and salts in the soil, the effect of irrigation on the physical and chemical properties of soil, the control of weeds, methods of irrigation and drainage and selection of crops for saline, alkaline and waterlogged soils. Evolution of short-duration varieties may be necessary to enable farmers to raise three successive crops in a year. The Commission noted with regret that in some of the projects enough, and timely, attention had not been given to research work. The importance of agronomic and irrigation research for the speedy development of ayacuts cannot be overemphasised. We recommend, therefore, that for all major and medium irrigation projects adequate arrangements for research should be made, either through the existing research stations or by setting up new ones. In large-sized ayacuts, one, and if need be more than one, research station should be set up for different soil types, well in advance of the release of irrigation water.

7.43 The research stations should celebrate 'Farmer's Day' twice a year, once during the kharif and again in the rabi season, to establish a rapport between specialists and farmers. Batches of farmers from all

over the ayacut should be assembled and the details of each research project should be explained to them. They should be given full opportunity to discuss the implications of the research findings with the specialists and also to seek solutions to their problems. This will develop a two-way traffic between the specialist and the farmer, and create the atmosphere of confidence necessary for the ready acceptance of new methods and technology.

7.44 *Demonstrations* : Demonstrations on farmers' fields are now universally accepted as the best way of persuading them to adopt new agricultural techniques. In the Nagarjunasagar Project, before the advent of irrigation, a large number of 5 acre demonstration plots were laid on farmers' fields to acquaint them with the techniques of raising light irrigated crops. Special staff was appointed for the purpose by the project authorities. In the Parambikulam Aliyar Project of Tamil Nadu, advance action was taken to set up one demonstration plot for every 200 hectares. In Bellary district (Tungabhadra Project), 460 demonstrations on soil and water management have been laid on farmers' fields to acquaint them with the techniques of farming under light irrigation. The Mysore Government is already planning to hold such demonstrations in the Upper Krishna ayacut before canal water actually becomes available. The Maharashtra Government has staged no less than 1,058 demonstrations on farmers' fields under 10 projects in 1968–69. These demonstrations have served as pace-setters, introducing farmers to new crop and water management practices. The Commission recommends that even before the development of irrigation potential a sufficiently large number of demonstrations should be laid on farmers' fields in major and medium ayacuts.

7.45 *Farmers' training* : The demonstrations mentioned above serve as focal points, in a limited way, for disseminating the new technology, but greater efforts are required if the community of farmers in a project area as a whole is to be trained in the improved technology relating to irrigated agriculture. Most of our farmers cannot make use of printed material. The use of audio-visual aids, therefore, assumes significance in training. The centrally-sponsored scheme for training farmers, currently in operation, envisages the training of farmers through the medium of national demonstration plots, laid by research workers on farmers' fields. Farming operations are demonstrated by research workers and explained with the help of audio-visual aids. This is linked up with discussion groups at the village level, supported by broadcasts on All-India Radio. The district is taken as a unit, and special staff is provided for training and educating farmers. To enable the speedy development of

an ayacut, the Commission recommends that additional districts sanctioned under the scheme, should, as far as possible, be located in the ayacuts of major and medium projects in different States.

The use of All-India Radio for disseminating knowledge on modern agriculture is certainly useful, but the Commission feels that even more striking results can be achieved through television which enables the farmers to see the results of improved practices. A modest beginning has already been made with television services in and around Delhi. By an agreement signed between United States of America and India in 1969, the United States National Aeronautics and Space Administration (NASA) will make available to India for one year the services of a satellite which will provide facilities to 5,000 villages. India is planning to have its own satellite by 1975. The Commission recommends that the major and medium ayacuts should be given priority in the television programme to popularise improved technology.

Organising Inputs and Credit

7.46 *Supply of current inputs* : Good irrigated agriculture is not possible without an adequate supply of inputs like better seeds, fertilizers, pesticides, etc. The new high yielding varieties of crops are well known for their responsiveness to irrigation and to high doses of fertilizers. If these inputs are applied in the right quantity, and at the right time, yields can be improved substantially above the present levels. These crops are highly susceptible to pests and diseases, but timely treatment or preventive action can save them. Adequate arrangements for procuring seeds of new strains, fertilizers and pesticides, and their storage and marketing are essential. Since these seeds are available only in relatively limited quantities, a phased programme for multiplication to meet the requirements of the area has to be initiated. A crucial factor in fertilizer use is the timely availability of supplies. Adequate quantities of different types of fertilizers should be moved sufficiently in advance, and kept ready for distribution. So, too, with pesticides. In the IADP districts, agencies like Cooperatives, State Agriculture Departments and private dealers provide these services. With the augmented extension staff which we have already recommended, the ayacut areas are not likely to face any major difficulty in this regard. However, if any unforeseen problems arise, they should receive the immediate attention of the ayacut development authority.

7.47 *Draught power for cultivation* : We have already mentioned that in newly irrigated areas the availability of manpower and cattlepower is generally low. Irrigated agriculture requires better soil prepara-

tion, and in case of multiple cropping, this operation has to be repeated after every cropping. In multi-cropped areas, the intervening period between two successive crops for soil preparation is short. Hence the need for tractors. In para 7.38, we have dealt with the need for tractors and other machines for land-shaping, but the use of tractors in irrigated agriculture for field preparation is equally important. The Agro-Industries Corporations of States have been set up to provide tractors on hire, hire-purchase or by sale. Loan requirements for the purchase of tractors have to be met by the Agricultural Finance Corporation, Nationalised and other Banks, and medium- and long-term loaning cooperative institutions. Cooperatives are assisting farmers with medium-term loans for the purchase of cattle etc.

7.48 *Credit needs* : The credit needs of modern agriculture are of a much higher order than those of traditional agriculture. It has been estimated that Rs. 500 per hectare is needed for the purchase of inputs like improved seeds, fertilizers, insecticides and pesticides. An equal amount is needed for other cultivation expenses. Only a few well-to-do farmers can afford to meet such expenses from their own resources. A majority of the others need assistance. In the past, a major part of their need for credit was met by the money-lender, professional and non-professional, with the cooperatives playing only a minor role. It has been estimated that cooperatives are now meeting about 25 per cent of credit needs of the country as a whole, leaving about 70 per cent to private money-lenders. The remaining 5 per cent is met by government sources and commercial banks. In some States with an advanced cooperative movement such as Maharashtra and Gujarat, however, about half the farm finance comes from cooperatives. Cooperatives in the new ayacut areas are generally weak, and need considerable strengthening before they can cope with new demands. Even then, they alone will not be in a position to meet the entire credit needs of these areas; hence a multi-agency approach should be adopted in planning credit facilities.

7.49 The Commission has noted with satisfaction the change brought about by the nationalisation of 14 major Banks. It has led to an improvement in the policy of commercial banks towards rural financing. The Lead Banks scheme envisages a multi-pronged attack on the problem of under-development in districts. The main areas of action would include branch expansion, stepping up of credit supplies, the identification of major bottlenecks in the development of agriculture and suitable remedial steps. In this effort the Lead Bank is expected to associate with other banks and cooperative institutions functioning in the district and at other levels in the State. In fact, problems of ayacut areas

are already receiving the attention of some Lead Banks, and they should be able to play a crucial role in ayacut development.

7.50 We have already referred to the medium- and long-term loan requirements of farmers, and the role of Land Development Banks and the Agricultural Refinance Corporation in financing land-shaping works in paras 7.34 to 7.36. Other agencies involved in midium- and long-term financing are the Agricultural Finance Corporation and the State Agro-Industries Corporations, which provide an additional line of credit for the supply of farm machinery on hire-purchase. The former has been set up by the commercial banks to give loan assistance, directly or indirectly, to farmers, to finance activities such as the energisation of wells. farm mechanisation, processing of agricultural produce, construction of storage godowns and silos, transportation and marketing of produce etc. From its inception in 1968 till the 31st January 1971, the Corporation has sanctioned 35 schemes, estimated to cost Rs. 1.239.4 million, of which its committed assistance amounts to Rs. 207.5 million. With the involvement of the Cooperatives and Commercial banks in development activities and the backing provided by the Agricultural Refinance Corporation and other similar agencies, it is reasonable to expect that the financial needs of ayacuts will be adequately met.

7.51 We have stated in para 7.10 that sizeable public investments are needed for agricultural research, establishment of markets, warehouses and storages, development of roads, transport and communications etc. if ayacut areas are to develop smoothly and quickly. We have recommended that these items should form part of the ayacut development plan and adequate provisions made for them in the project estimate itself. These funds will, thus come under the Plan allocation and no separate agency for financing them need be prescribed.

Area Development Programme

7.52 During the formulation of the Fourth Five Year Plan, the Government of India felt that the development of regulated markets, all-weather roads and storages had lagged because the State Governments could not find money for it. The Government, therefore, started a scheme known as the Area Development Programme' and allocated a sum of Rs. 150 million for it in the Fourth Five Year Plan. The Programme was to be treated as centrally sponsored and the money given for the purpose was to be treated as a grant. The works were to be executed through the State Governments. Before any command area became eligible for inclusion in the above Programme, the State Government

concerned had to agree to provide funds for all other services and works listed in the plan. The Programme was started in the first year of the Plan and has been extended to the following command areas :

(1) Kosi (Bihar)
(2) Nagarjunasagar (Andhra Pradesh)
(3) Tungabhadra (Mysore)
(4) Rajasthan Canal (Rajasthan)
(5) Mahi-Kadana (Gujarat)
(6) Tawa (Madhya Pradesh)
(7) Kangsabati (West Bengal)
(8) Cauvery (Tamil Nadu)
(9) Pochampad (Andhra Pradesh)
(10) Jayakwadi Stage I (Maharashtra).

Later, the Government of India increased the allocation from Rs. 150 million to Rs. 250 million. The actual expenditure on this programme for the year 1970–71 was of the order of 26 million rupees and there is a provision of 30 million rupees for 1971–72. We consider that the construction of roads, the creation of market facilities and the construction of storages are important items of ayacut development. We hope that the tempo of the activities envisaged under the programme will gain momentum and have a larger coverage.

Infrastructure

7.53 Irrigated agriculture is market oriented. It creates large surpluses for sale. We have already made a brief reference to the vital role of mandis, roads and railways in the development of Canal Colonies. With the gradual change-over from subsistence to commercial farming, the ayacut would need organised and regulated markets to protect the grower from exploitation. This can be ensured by notifying marketing centres as 'regulated markets' under the Agricultural Produce Markets Acts of the States. Efforts should be made to strengthen the existing markets and to open new market yards where trade practices can be regulated. The role of an assured market, and remunerative prices for farm produce can hardly be over-emphasised.

7.54 The marketing centres should be developed into focal points of rural life. They must have shops and depots for the supply of inputs—seeds, fertilizers, pesticides, agricultural implements—and consumer goods to meet the farmer's daily demands. One of the Nationalised Banks must open a branch office, and postal, telegraph and telephone services must be made available. The Land Mortgage Banks should operate from the marketing centre. The system of cooperative credit

societies must gravitate to this point. Consultancy services for the farmer. and higher educational institutions for the farmers' children may also be located there.

7.55 The market should be located within easy distance of villages. The roads and transport system should be planned in a manner to permit vehicular traffic all the year round, at least on main roads. Each village in the ayacut should have reasonable access to the main road. Among the canal engineers there is a difference of opinion as to the feasibility of using canal banks as traffic bearing roads. The Commission has. however, no doubt that in some areas where the canal banks are of the required specifications and width, they can be used advantageously for carrying traffic. The Commission, therefore, recommends that wherever canal banks are of the required specification, they may be developed as ayacut roads. Each case will, however, have to be examined on merits.

7.56 *Warehousing and storage* : The marketing centres will need new and additional storage accommodation. The storages should be modern and facilities should be made available for storing produce for reasonably long periods to enable farmers to obtain better prices. Necessary arrangements should also be made to enable farmers to obtain advances on stored produce, through the construction of warehouses by the Central or State Warehousing Corporations, or by Cooperative Societies. In addition, there should also be godowns for storing agricultural inputs like seeds, fertilizers, pesticides, etc. The demand for such storage and warehousing facilities is bound to increase as irrigation gets stabilised and agricultural production increases.

7.57 *Development of Agro-industries* : With the growing availability of raw materials, the developing ayacuts are bound to attract some industries, particularly processing units such as rice mills, flour mills, cotton ginning and pressing factories, spinning mills, ground-nut decorticator and pressing factories, sugar factories, food preservation factories etc. Large-sized ayacuts will consume large quantities of industrial inputs such as fertilizers, pesticides and machinery such as tractors, oil-engines etc. which would need servicing. The State Gc vernments are advised to make a survey of the ayacut areas to assess the r immediate and long-range industrial potential. We recommend that the State and Union Governments and the Planning Commission, should pay adequate attention to the interest of large-sized ayacuts in locating agro-industries both in the private and public sectors. Institutions such as the Industrial Finance Corporation, the Unit Trust, and the Life Insurance Corpora-

tion, already provide financial assistance to private industrialists. The Agricultural Finance Corporation also makes available some funds for the development of agro-industries. Thus, there should be no need to provide any separate funds for industrial development in the development budget of the ayacut. The Commission, however, recommends that in planning ayacut development, suitable sites should be earmarked for the establishment of industries. During its tour the Commission observed that under some projects the development of areas localised for sugarcane was rather slow. We were told that the reason for this was the absence of a sugar factory in the neighbourhood. We recommend that wherever a sufficient area is localised for sugarcane, arrangements for setting up a sugar-mill may be taken in hand.

Other Problems

7.58 *Night Irrigation* : The Tungabhadra Project was designed like other projects to give continuous day and night irrigation. Night irrigation in rice fields, where water flows from the upper to lower fields, offers no special problem. The Commission was, however, informed that farmers of light irrigated crops, who have to regulate and personally supervise the flow of irrigation at night, were not using water during the night hours, and that water was going waste. The situation was sought to be remedied by putting up separate outlets for heavy and light irrigation, the former to operate at night and the latter in the day time. We were told that this arrangement has failed to solve the problem. The Commission recommends that the State Governments should examine if the warabandi system of the north could be introduced with advantage in areas where night irrigation is not practised. Rosters allocating hours and days during which the farmers under the outlet would be permitted to draw water, should be fixed. In preparing the roster, care should be taken that farmers should, as far as possible, get day and night irrigation in alternation. Farmers who fail to make use of the allocated water would not be eligible for water out of turn.

Unauthorised Irrigation

7.59 On the Tungabhadra Left Bank Canal the Commission came across several colonies of settlers who had sold their lands in the delta areas and had bought land in the new ayacut areas. Such settlers from the rice growing areas began to grow rice in the areas nearest the outlets earmarked for light irrigated crops. This has led to waterlogging and in some places to salinity, in the fields below. In addition, fields lower

down were denied their share of water. We suggest the authorised cropping pattern should be enforced.

Colonisation of Commands

7.60 We have referred to the low density and inadequate manpower in some of the ayacut areas. In the command area of the Tungabhadra Project the density of population ranged from 180 to 200 persons per square mile. We are glad to learn that a colonisation scheme to settle 5,000 repatriates from Burma and Ceylon has been taken up in the Sindhanor taluq of the Raichur district. For this purpose, 2,023 hectares have been acquired and levelled by the Field Mechanisation Unit of the Union Ministry of Rehabilitation. The total cost of the scheme is estimated at Rs. 7.3 million. The first batch of 153 families arrived in 1969. It had reaped the kharif crop and was expecting the rabi crop. There was, however, also some unplanned migration, specially from the Andhra delta areas. Similar conditions are reported to prevail in the ayacut under the Hirakud Project, where unplanned migration of farmers had taken place.

7.61 The Rajasthan Canal will irrigate almost waterless and very scantily populated areas. For this project, the Government has set up a colonisation department to arrange the systematic movement of colonists. We are of the opinion that wherever people have to be moved from other areas to irrigated ayacuts or commands, the movement should be carefully planned. We have already commented upon the great care taken in selecting colonists for the Punjab Canal Colonies. In selecting farmers for new areas, social and economic considerations should be kept in mind. We would, therefore, recommend that the selection of colonists should be confined only to landless people, specially Harijans and farmers with uneconomic holdings. Colonisation needs hard labour, and physically unfit and socially undesirable persons must be excluded.

Promotional Water Rates

7.62 As discussed in Chapter XI in greater detail, giving concessional water rates in the initial years of a new irrigation system, has proved useful in promoting speedy development of its ayacut. The Commission recommends this as a general practice in areas where cultivators are new to irrigated agriculture.

CHAPTER VIII

DROUGHT AFFECTED AREAS

Our terms of reference have not defined the chronically drought affected areas'. In what follows we have not drawn any distinction between chronic drought areas where drought is more or less endemic and other areas affected by drought from time to time. Our reasons are as follows. Drought is a meteorological phenomenon, and the vulnerability of any area to drought depends on the extent to which physical and climatic conditions play an adverse role in creating an unstable agriculture. The difference, therefore, between chronic drought areas and drought areas is one of frequency. Moreover, our study of the problem has revealed that areas which suffer from chronic drought are only a small part of the total area affected by drought. The chronic areas are confined to west Rajasthan, particularly the districts of Jaisalmer, Barmer, Jodhpur and Bikaner, and Kutch in Gujarat. In this desert or semi-desert tract, which is largely covered by sand dunes, the scope for irrigation is remote, and very little can be done to improve conditions beyond making provision for drinking water and fodder to sustain a largely pastoral economy. On the other hand, there are other areas in Rajasthan, Gujarat and peninsular India where drought is not endemic, but occurs with sufficient frequency to warrant special measures. In these areas there remains considerable scope for providing irrigation to stabilise agriculture.

8.2 We have also had to depart from the strict letter of the Commission's terms of reference in dealing with food deficit areas. Where the food deficit arises from the instability of agriculture, because the area is susceptible to drought, it falls fairly and squarely within our terms of reference. However, there are areas where the food deficit is a result of other factors, such as over-population. For example, Kerala, which gets 2,990 mm. of rainfall and is traversed by a large number of rivers, and has good soil, is a food deficit area. We feel that in the context of droughts and food deficiency, Kerala and like areas can safely be omitted, because any food shortage there can be made up by imports from surplus areas, or by drawing upon the food stocks maintained by the Centre.

We do not feel called upon, therefore, to suggest a special programme for irrigation in Kerala or other similar parts of the country.

8.3 Finally, there is the question of suggesting a minimum programme of irrigation for drought districts. At present, about 13 per cent of the cropped area of the drought affected region is irrigated. This is likely to rise to about 19 per cent when the schemes under execution are completed. Even so, as much as 81 per cent will remain without irrigation. In the drought areas of Madhya Pradesh, Mysore, Maharashtra, and Gujarat, where the present level of irrigation is even lower than 13 per cent, the position will be worse. The extent of the area irrigated in the drought districts is likely to go up to about 25 per cent of the cropped area when all the works which the States have proposed for these districts, are completed. It is possible that some of the proposed schemes may not prove to be feasible, and some, on the inter-State rivers may have to be dropped, if competing schemes for the use of water are given precedence. For these reasons we feel that the needs of the drought areas will not be adequately met by any *minimum* programme of irrigation. What is needed is a *maximum* programme, because even if such a programme is implemented drought areas will lag behind, since only 25 per cent of the cropped area will come under irrigation as against 50 per cent for the country as a whole.

Dimensions of the Problem

8.4 The problems posed by drought vary from area to area, depending on the amount of rainfall and its variability, and also the extent to which irrigation has been developed. Assuming that districts which receive less than 750 mm. of rainfall per annum are liable to drought, there are about 77 such districts in the country, which account for about 34 per cent of the net sown area. Excluding such of these districts as have developed irrigation on an adequate scale, there still remain 50 districts, accounting for one-fourth of the cultivated area in the country, which could be considered as vulnerable to drought. There are, in addition, another 22 districts in Maharashtra, Gujarat, Madhya Pradesh, Mysore, Rajasthan and Uttar Pradesh, accounting for nine per cent of the cultivated area of the country, which get between 750 mm. and 850 mm. of rain. This rainfall is of doubtful efficacy and the districts have very little irrigation. They should also, therefore, be considered vulnerable. If these areas are taken into account, as much as one-third of the cropped area in the country would appear to be susceptible to drought.

8.5 The problem also has a socio-economic dimension. There have

been glaring disparities in income and living standards between the dry and drought areas on the one hand, and the irrigated and high rainfall areas on the other. These differences have been further accentuated as a result of the recent advances in agricultural technology which are more suited to irrigated areas. Such differences, if allowed to persist, would give rise to marked inequalities in income between social groups, and to regional imbalances.

8.6 That irrigation, to the extent it can be provided, would give protection to many of these areas, is borne out by the experience of Punjab, Haryana and west Uttar Pradesh, which were highly precarious tracts, frequently affected by famine before they were provided with irrigation in the last century. Irrigation completely changed the face of agriculture in these areas. A more recent example is that of the Gang Canal in Rajasthan which transformed parts of Ganganagar, one of the intensely arid districts in the State, into a prosperous agricultural tract.

8.7 We must remember, however, that in most of the areas which we have just mentioned, there were dependable sources of water which could be harnessed for irrigation. On the other hand, most of the drought areas in the country are not so favourably situated with respect to such natural sources. Large parts of Rajasthan, for example, have no sizeable rivers which can be harnessed. The Saurashtra and Kutch areas of Gujarat have only small rivers. Even these rivers are seasonal and their dependable flows are not sufficient to provide sizeable irrigation. A similar position exists in parts of Haryana, Madhya Pradesh, Maharashtra and Mysore.

8.8 In these areas, transportation of water from other basins as was done in the case of the Gang Canal where water was brought from the Sutlej basin or exploitation of groundwater, may perhaps provide some answer to the problem of drought. The development of suitable techniques to conserve moisture would also be of great value.

8.9 The example of Israel is relevant in this context. It is a semi-desert country with highly undulating terrain and sandy soils, with an annual rainfall of 500 mm. or less in most parts. There is a shortage of rain during the summer months, which is the season for growing crops, and this makes irrigation essential. The sources of irrigation in Israel are extremely limited, and while 95 per cent of these sources are in the north, the land to be irrigated lies in the south. Against these tremendous odds Israel has succeeded in building up a highly modernised agriculture. It has constructed an irrigation grid to convey water from the north

to areas in the southern deserts. It has also developed water-saving techniques, both in transmission and distribution, so as to achieve the maximum production per unit of irrigation water. Not only has it made the desert bloom. but it has developed a sophisticated and specialised agriculture which concentrates on growing highly priced, off-season crops for home consumption and for export. These developments in Israel provide valuable lessons to us for the development of our drought areas and in particular of the arid and semi-arid regions.

8.10 At the time when the First Irrigation Commission began its work. the areas which were most susceptible to scarcity were the whole of Rajasthan and Gujarat, the western, south-eastern and southern parts of Uttar Pradesh, Punjab (excluding the northern districts) and areas in peninsular India stretching from Nimar in Madhya Pradesh through Maharashtra, the interior districts of Mysore and south-west Andhra Pradesh down to the northern districts of Tamil Nadu. Other vulnerable areas were located in north Bihar, particularly the tracts bordering on Nepal.

8.11 As a result of the recommendations of the First Irrigation Commission, a large number of protective irrigation works were taken up in many parts of these areas. The more important were the Ken Canal in Uttar Pradesh, the Girna, the Godavari, and the Nira Right Bank Canals in Maharashtra, the Cauvery-Mettur Project in Tamil Nadu, the Krishnarajasagar Project in Mysore and the Nizamsagar Project in Andhra Pradesh. However, none of the recommendations of the Commission regarding protective works in Gujarat were implemented, and very little was done in the erstwhile Rajputana and Central India States.

8.12 Prior to Independence, the Government's irrigation efforts were largely confined to what now constitute the territories of Haryana, Punjab, Uttar Pradesh, Andhra Pradesh, and Tamil Nadu. The first two States were one Province at the time and together accounted for 22 per cent of canal irrigation in 1949–50 and the others for 23 per cent, 17 per cent and 11 per cent, respectively. The States highly vulnerable to drought, such as the erstwhile Bombay State, Mysore, Madhya Pradesh and Rajasthan accounted for only two to five per cent.

Drought areas as identified by the States

8.13 The Commission asked the State Governments to assist it in identifying drought areas and to let it know which of the following

criteria had been adopted in determining whether drought in the areas in question was chronic and called for special consideration :

(i) Meteorological data;
(ii) Revenue remissions;
(iii) The frequency of famine or scarcity; and
(iv) The availability of irrigation facilities.

While issuing the Questionnaire we did not define the words 'chronically drought affected', nor did we suggest the weightage to be given to any of the four criteria mentioned above. We left it to the States to give whatever weightage was considered appropriate in the context of local conditions. Generally speaking, the States have leaned on the side of liberality, and have listed as 'chronically drought affected' almost all areas that have suffered from droughts in the past, irrespective of the periodicity of such droughts. In view of the significant differences in physical features and rainfall even within a district, drought areas have been identified by all the States at the level of smaller administrative units, such as tehsil, pargana, taluk, block or thana. The areas identified by the States as being drought affected, are shown in Fig. 8.1.

8.14 We had also requested the India Meteorological Department to assist us in laying down criteria for the identification of drought areas. The Department has defined drought as a situation occurring in any area when the annual rainfall is less than 75 per cent of the normal. It has defined 'moderate drought' as obtaining where the rainfall deficit is between 25 to 50 per cent and 'severe drought' where the deficiency is above 50 per cent. Areas where drought has occurred, as defined above, in 20 per cent of the years examined, are considered 'drought areas', and where it has occurred in more than 40 per cent of years, as 'chronic drought areas'. We shall be discussing these criteria in greater detail later.

8.15 Before defining the areas which we consider to be drought affected, and for which we are recommending an accelerated programme of development, it is necessary to touch briefly on the criteria used by the State Governments to delineate drought affected areas.

The Governments of Maharashtra and Gujarat have been guided largely by the 'Fact Finding Committee' which was set up to survey the scarcity areas in Bombay State in 1958. This Committee had taken into consideration all the four criteria mentioned in our Questionnaire to the States. To the list drawn up by it, the Government of Maharashtra has added parts of Nasik, Osmanabad and Bhir districts, and the Gujarat Government has suggested that we might include more areas in Kutch.

8.16 The Government of Tamil Nadu appointed a study team on drought in 1966 to demarcate the vulnerable areas. This team based its findings exclusively on the data relating to rainfall and irrigation. On the assumption that successful farming is possible only where rainfall is 900 mm. or more, or where at least 35 per cent of the cultivated area is irrigated, this team identified 31 taluks where these minimum conditions were not present and which, therefore, required special attention.

The Rajasthan Government assumed that for an area to be declared drought affected, the ratio of good crop years to scarcity years should be 2 : 1 or less, and that 50 per cent of the villages in the area should be affected by drought.

The Mysore Government considered that drought areas were those which receive less than 400 mm. of rain during kharif and less than 150 mm. during rabi, with a variability of more than 30 per cent during each crop season, and a rainfall deficiency of more than 20 per cent during the crucial stages of crop growth.

Madhya Pradesh, Orissa, Haryana, Uttar Pradesh and West Bengal have also adopted all four criteria, while Assam has relied mainly on meteorological data. Andhra Pradesh, Bihar and Punjab have not furnished any data.

8.17 Since the basis on which the States have identified drought areas varies from State to State, no purpose would be served if we were to analyse the recommendations made by the States. We propose, therefore, to discuss the criteria which we have suggested for identifying drought areas.

The Criterion of Annawari estimates and Revenue remissions

8.18 Annawari is the system of estimating the condition of crops by visual assessment. It is assessed in terms of annas in the rupee.* In the south, a twelve anna crop is considered to be a normal crop. Where the crop is four annas or less the recovery of land revenue is suspended in full. Where it is between four annas and six annas, one-half of the land revenue is remitted. The frequency of the suspensions of land revenue over a period of time, can provide an indication of the frequency of drought.

8.19 The Krishna-Godavari Commission had examined 'Annawari' as a criterion for determining areas susceptible to drought. It found, however, that the rules and regulations relating to the suspension or

*(anna = 1/16 of a rupee).

remission of land revenue differed from State to State. and even from district to district in the same State. In some cases, that Commission found that the revenue suspended or remitted in a year exceeded the total amount of the dry assessment. Also, in the Jagir areas. no data was made available. That Commission also found that land revenue had been suspended or remitted in circumstances which were not governed by the general rules. and that the amount suspended or remitted had risen steadily over the years. which could not be attributed to adverse weather conditions alone. For example. during the decade 1941–1950, the amount suspended or remitted was three times the amount remitted in the decade 1931–1940. In subsequent years. the amount remitted was five times more than during the decade 1931–1940.

8.20 The Maharashtra Government, in its preliminary memorandum to us, observed that the subjective element in the assessment of annawari by village officers was so large as to vitiate any delineation of drought areas based on annawari. We support this conclusion.

Meteorological criteria

8.21 Drought is the result of an imbalance between the soil moisture and evapo-transpiration needs of an area, over a fairly long period, so as to cause damage to standing crops and a reduction in crop yield. The basic characteristic of drought is a steady rise in temperature, in addition to the absence, or the severe deficiency, of rainfall over a fairly long period. Several factors, such as precipitation, temperature, wind velocity, sunshine, soil texture, soil moisture and antecedent rainfall interact to produce this situation. However, the key role is played by rainfall and the crucial variables are its distribution, its variability and its capacity to meet evapo-transpiration needs.

Distribution of rainfall

8.22 We have discussed the distribution of rainfall in the country in Chapter II. For our purpose here, it is enough to draw attention to the fact that large tracts in the country depend for their rainfall on the south-west monsoon, which is not only concentrated in a brief period of four to five months, but is unevenly distributed, both in space and time. In most parts of the country, 80 per cent of the annual rainfall is received from June to September from the south-west monsoon. The figures rise to 90 per cent in Gujarat, Rajasthan and Madhya Pradesh. Along the coastal strip from Alleppey to Bombay, on the Western Ghats and in Assam and adjoining sub-Himalayan West Bengal, the

annual average rainfall is more than 2,500 mm. It is above 1,000 mm. along the West Coast and in areas to the east of longitude 78°E. It is less than 1,000 mm. in the area between the Vindhyas in the north and the Western and Eastern Ghats and in the tracts to the west of the Yamuna and Chambal rivers. Over large areas of Punjab, Haryana, Rajasthan and Gujarat, the average is below 600 mm. and the western-most parts of Rajasthan get as little as 100 mm. In peninsular India, the tract extending southwards from Dhulia in Maharashtra to Chitradurga, Anantapur and Cuddapah receive less than 600 mm. of rain.

Variability in rainfall

8.23 In Chapter II, we have drawn attention to the variability and unreliability of rainfall over large parts of the country. This makes for a high degree of vulnerability to drought. The only regions which are not thus vulnerable are Assam, West Bengal, Orissa, the West Coast and certain parts of Central India.

Adequacy of rainfall

8.24 If agriculture is to be successful there must be enough rainfall to meet the soil evaporation and transpiration needs of crops. For all practical purposes, the water needs of an area are indicated by the potential evapo-transpiration (PE), that is to say, the loss of water in the form of evaporation and transpiration, from an extensive vegetative cover under conditions of unlimited water supply. In Chapter II we have already given an indication of the monthly and annual values of PE obtaining in different parts of the country.

8.25 Adequacy of rainfall, which has also been defined as the net water balance in an area, can be studied by comparing the precipitation received, with PE, taking also into consideration the characteristics of the soil in the area, particularly its water-holding capacity. Accordingly, four main climatic regions can be distinguished, namely, the arid zone, where a constant water deficit is typical; the semi-arid zone which periodically suffers from lack of water; the sub-humid zone which enjoys a seasonal water surplus and the humid zone which has a surplus of moisture throughout the year. The position of the arid and semi-arid regions is shown in Fig. 8.2.

8.26 It will be seen from this figure that the Saurashtra-Kutch region of Gujarat, the western half of Rajasthan and parts of Haryana are in the arid zone where there is a constant water deficit. Conditions very

close to aridity prevail in the rain-shadow tract along the leeward side of the Western Ghats from Nimar in Madhya Pradesh through the districts of Khandesh, Ahmednagar, Sholapur (in Maharashtra), Gulbarga, Bijapur, Raichur and Bellary (in Mysore) to Anantapur, Kurnool and Mahbubnagar districts (in Andhra Pradesh). A small area within this tract around the Anantapur-Bellary chord also has conditions of aridity.

Semi-arid regions comprise areas where precipitation meets only one-third to two-thirds of the evapo-transpiration needs. These regions cover almost the entire peninsula east of the Western Ghats and extend to portions of west Madhya Pradesh, west Uttar Pradesh, Haryana and Punjab. Semi-arid conditions also occur in parts of the Gaya, Patna and Monghyr districts of Bihar.

Frequency of shortfall from normal rainfall

8.27 It will be noticed that the definition of drought given in para 8.14 does not take into consideration the timeliness of rainfall. However, because of differences in cropping patterns and distribution of rainfall from region to region, it would be difficult to qualify the definition of drought with sufficient exactness by introducing this element. We have, therefore, decided that the definition of drought given by the India Meteorological Department should be accepted.

8.28 Using the annual and south-west monsoon rainfall data from 1901 to 1960 for about 500 stations which are fairly representative of the country, drought and chronic drought areas have been identified as follows :

(a) Drought areas : (20 per cent probability of rainfall departures of more than (—) 25 per cent from the normal).	(1) Gujarat, Rajasthan and adjoining parts of Punjab, Haryana, west Uttar Pradesh and west Madhya Pradesh.
	(2) Madhya Maharashtra, Interior Mysore, Rayalaseema, south Telangana and parts of Tamil Nadu.
	(3) A small portion of north-west Bihar and adjoining east Uttar Pradesh.
	(4) A small portion of north-east Bihar and adjoining portion of West Bengal.

(b) Chronically drought affected areas (40 per cent probability of rainfall departure more than (—) 25 per cent).	Western parts of Rajasthan and Kutch.

8.29 It appears that most of the areas identified as susceptible to drought very clearly fall within the arid and semi-arid zones. Chronically drought affected areas are identical with the intensely arid zone. The figure also shows that areas of frequent scarcity and famine in the past are broadly the same as the drought areas indicated in the figure. In this area, rainfall is less than 1,000 mm. and falls steadily as the isohytel moves from border line to hard-core areas. Rainfall density and rainfall variability show a close inverse relationship, the latter increasing as the former decreases. Severe drought areas record the lowest rainfall and the highest variability. Drought may also occur outside this zone in areas like Vidarbha in Maharashtra, Chhatisgarh in Madhya Pradesh and areas in the east in the sub-humid regions which receive more than 1,000 mm. of rainfall with a fair degree of reliability. The problems of such areas are different from those of the arid and semi-arid regions and are not being considered here.

8.30 However, all the districts and taluks which comprise the drought zone are not equally vulnerable to crop failures. Protective irrigation to stabilise agriculture has been developed, or is being developed, in some districts or taluks and we consider that those of them which enjoy a minimum percentage of irrigation, should be excluded from the list of drought affected areas.

8.31 On these considerations, therefore, the minimum criterion for identifying areas susceptible to drought is that the probability of critical rainfall shortage should be 20 per cent or more and that there should be an adverse water balance. Once the broad drought zone has been demarcated according to this criterion, districts or taluks in it can be examined from the point of view of the availability of irrigation to identify those which require special attention.

8.32 While it is difficult to suggest any absolute percentage of irrigation which could be considered sufficient for drought areas, judging from the criteria followed in the past we feel that it would be safe to consider any taluk or equivalent unit, where 30 per cent or more of the cultivated area is irrigated, as having reached a stage which would enable it to sustain a reasonably stable agriculture and to be reasonably protected against drought.

8.33 From the list of the taluks furnished by the State Governments, we have excluded those which lie outside the drought zone and also those where 30 per cent of the cropped area is irrigated. We have likewise excluded taluks which form parts of districts with adequate rainfall or irrigation, if such taluks comprise only a small portion of these districts. After making these adjustments to the list, we find that most of the drought areas which need special attention lie in the States of Mysore, Andhra Pradesh, Gujarat, Rajasthan, Maharashtra and Tamil Nadu. A list of the districts and taluks affected is shown in Appendix 8.1 and Fig. 8.2.

The State-wise position of tehsil/taluk area and population subject to drought is indicated in the following table :

Table 8.1
Area and Population affected by drought

State	Number of districts	Number of tehsils/ talukas	Geographical area (000 hectares)	*Population (000 persons)
1	2	3	4	5
Andhra Pradesh	7	60	9,700	9,410
Gujarat	11	60	7,070	5,480
Haryana	3	6	810	1,490
Madhya Pradesh	9	24	4,090	3,070
Maharashtra	9	45	6,250	6,930
Mysore	12	88	10,350	11,580
Rajasthan	9	19	7,480	2,760
Tamil Nadu	7	24	3,980	7,360
Total :	67	326	49,730	48,080

*1961 census.

The hard-core areas of drought comprise about 16 per cent of the total geographical area of the country and account for over 11 per cent of its population.

8.34 Fig. 8.2 shows the areas identified by the India Meteorological Department as having an adverse water balance and a rainfall which displays a frequent tendency to fall short of the normal. If this figure is superimposed on Fig. 8.1, which shows the drought affected areas identified by the States, it will be seen that there is a high degree of compatibility between the two in Haryana, Rajasthan, Gujarat, Maharashtra, Mysore, Andhra Pradesh and Tamil Nadu.

8.35 However, in the eastern and central regions of the country, where the aggregate rainfall is higher than the average, there is a high degree of disagreement. A large number of taluks or blocks in Orissa and West Bengal and many in the eastern districts of Madhya Pradesh and Uttar Pradesh have been identified by the States as being drought affected.

8.36 We feel that the inclusion of these areas in the category of drought areas is not justified. For instance, the identified areas in Assam, Orissa and West Bengal receive more than 1,000 mm. of rain during the south-west monsoon and more than 1,200 mm. annually, with a variation of about 20 per cent. We consider that this amount of rainfall is more than adequate for raising successful crops.

Similarly, the areas identified in east Madhya Pradesh and east Uttar Pradesh also receive well over 1,000 mm. of rain annually and the coefficient of variability is 20–25 per cent. Here also, the rainfall is adequate. We have, therefore, excluded these areas.

Development of irrigation in Drought Areas

8.37 A realistic approach to the formulation of an irrigation programme for drought areas involves not only an inventory of all existing irrigation works and an appraisal of their performance, but also an assessment of the scope for expanding irrigation by improved water management and the conjunctive use of surface and groundwater. Dug-wells and tanks are, by and large, the most important sources of irrigation in the drought areas. Unfortunately, it has not been possible to collect reliable information about minor sources of irrigation, talukwise. Even for districts, firm data is not available to assess the irrigation potential from surface and groundwater sources.

8.38 The most striking feature of the drought zone is the scarcity of sizeable irrigation sources, like perennial rivers, and this implies that greater stress must be laid on developing irrigation in these areas through smaller works, like anicuts, bandharas, tanks, wells etc. This requires an intimate knowledge of local conditions. We feel, therefore, that it is not possible to deal with the irrigation development by taluks.

We have perforce to treat the district as a unit for discussing the irrigation potential of surface water. For the purpose of detailed planning, however, we would like the States to treat a taluk or an equivalent area as the unit. The total irrigation possibilities from all sources, including wells, tanks and other minor works should be taken into account.

8.39 The priorities in any programme to develop irrigation for

drought areas should include the following:

(i) The improvement of irrigation works so as to stabilise existing irrigation and to extend irrigation with available supplies.

(ii) The expeditious completion of the irrigation works which have been taken up.

(iii) The investigation of further possibilities to increase irrigation from surface and groundwater and through inter-basin transfers of water to cater to the areas which are deficient in both surface and groundwater.

Improvement of existing works

8.40 There are a number of large irrigation works in the drought areas whose performance has not come up to expectations. Structural deficiencies, lack or inadequacy of storage, and loss of water due to seepage from unlined canals, distributaries and field channels are some of the factors responsible. Traditional irrigation practices also result in the wasteful use of water. This problem is discussed in greater detail in Chapter IX. However, the urgency of improving existing works in drought affected areas to conserve water and to economise its use can brook no delay. We recommend, therefore, that necessary improvements to these works should be attended to without delay.

8.41 During our tours of drought areas, we heard many complaints about the drying up of tanks and percolation wells, and about stored water turning brackish. When we visited Ramanathapuram in Tamil Nadu, in May, 1971, we inspected two tanks and were told that they had not filled up for a number of years. Though there were a number of wells in the ayacut of these tanks the water in them was not sufficient for pumping. Complaints were made to us when we toured Marathwada in Maharashtra and Rayalaseema in Andhra Pradesh, that a fair number of ex-malguzari tanks had fallen into disrepair. We recommend that these tanks should receive immediate attention and that sufficient funds should be provided to repair and renovate them.

8.42 During our visit to the worst drought affected areas of Maharashtra, we saw the beneficial effects of percolation tanks on wells within their zone of recharge. In Gujarat, appreciable benefits are reaped from the construction of check dams on streams and rivulets. Although percolation tanks and check dams do not provide direct irrigation, their contribution in firming-up and augmenting supplies in nearby wells, and thus facilitating irrigation has now been established. Both the Maharashtra and the Gujarat Governments place great reliance

on these works in their minor irrigation programmes. We recommend that in areas where the groundwater level is low and irrigation from wells is precarious, special attention should be given to the construction of percolation tanks, check dams, etc.

8.43 The economic use of water assumes greater importance in drought areas. Countries like Israel, which are more unfavourably placed than India with regard to water, employ new methods, such as sprinkler and drip irrigation with advantage. In Israel, as much as 90 per cent of irrigation is by sprinklers. Drip or trickler irrigation has also been employed to reclaim some highly saline desert areas, and to develop them for growing high-value, off-season crops for home and foreign markets. In Chapter VI, we have emphasised the desirability of extending sprinkler and drip methods of irrigation to the arid and semi-arid tracts of this country. We have suggested that more research should be done to identify the areas, conditions and crops which call for sprinkler and drip irrigation, and to demonstrate the benefits of these methods on farmers' fields so as to make them popular. Although, the initial investment on these systems is high we consider that in selected areas these methods will, in the long run, prove to be of great value. We are of the opinion, that it is necessary for the Government or for institutional agencies to provide liberal loans for the setting up of sprinkler or trickler irrigation in the drought zone. In the initial stages, it will be necessary to subsidise a part of the cost of installing these systems. It may also be examined whether the financial agencies can advance money at concessional rates of interest.

Expeditious Completion of Continuing Works

8.44 A State-wise list of all continuing major and medium works which are of great and immediate concern to the drought areas is given in Appendix 8.2. The total cost of these projects, as currently estimated, is Rs. 11,000 million.

8.45 Two factors which have impeded the progress of these works, are : (a) the high cost and inadequate financial resources to meet the needs of various competing programmes of economic development, and (b) inter-State disputes relating to the use of the water of inter-State rivers. It is a matter of concern that a large number of schemes on which sizeable investments have already been made are being carried over from Plan to Plan. The following table indicates the estimated cost of the continuing projects, expenditure incurred on them up to the end of 1970–71 and the expenditure to be incurred State-wise :

Table 8.2

Cost of continuing works and expenditure incurred on them up to the end of 1970-71

(Rs. million)

State	Total cost	Expenditure up to 1970-71	Expenditure to be incurred
1	2	3	4
Andhra Pradesh	2,536.1	2,039.5	496.6
Gujarat	1,633.1	370.6	1,262.5
Haryana	99.6	67.1	32.5
Madhya Pradesh	51.8	27.0	24.8
Maharashtra	2,801.0	821.7	1,979.3
Mysore	2,113.7	351.3	1,762.4
Rajasthan	1,207.3	749.9	457.4
Tamil Nadu	579.9	464.9	115.0
Total :	11,022.5	4,892.0	6,130.5

We recommend that priority be given to the expeditious completion of the continuing projects. Every effort should be made to complete them not later than the end of the fifth Plan period and adequate funds should be provided for expeditious completion.

8.46 In Chapter XV, we have suggested that in relation to inter-State water disputes, the Union Government should play an active role similar to that of the World Bank in the settlement of the Indus Water Dispute between India and Pakistan. We have no doubt that by suggesting alternative schemes and extending special assistance, the Union Government can do much to bring about speedy agreement in inter-State water disputes. This becomes all the more important in regard to rivers whose waters can be used for irrigation in drought areas.

New irrigation schemes in drought areas

8.47 The State Governments have suggested a number of new irrigation works for the drought areas. Important among them, which are likely to benefit more than 40 thousand hectares each, are the following :—

ANDHRA PRADESH

1. Upper Krishna (Extension)
2. Bhima
3. Tungabhadra Low Level Canal (Extension)
4. Sangameshwaram Stages I & II
5. Nagarjunasagar Stages II & III

GUJARAT

1. Sabarmati Reservoir
2. Karjan Reservoir

HARYANA

1. Sohna Lift Irrigation Stages I, II, & III

MADHYA PRADESH

1. Narmada Sagar

MAHARASHTRA

1. Khadakwasla Stage II
2. Koyna Irrigation Scheme Stages I & II
3. Bhima Lift Irrigation Stages I & II
4. Chaskaman
5. Kukadi Stage II
6. Nira Valley Project
7. Pravara River Project
8. Begampur Lift Scheme

MYSORE

1. Bhima Lift Irrigation
2. Bijapur Lift Irrigation
3. Upper Krishna Stage II
4. Bhima Irrigation
5. Tungabhadra Diversion
6. Unduthorehalla
7. Hemavati Stage II

RAJASTHAN

1. Anas Hydel Scheme
2. Baneshwar Hydel Project

8.48 A complete list of all the major and medium schemes suggested for drought areas in each State, is given in Volume II. These schemes are as reported by the States and include not only schemes tentatively included in the Fourth Plan but also those which have yet to be investigated. Some of the schemes have inter-State aspects and implications which have not been looked into at this stage.

8.49 The following table indicates the approximate cost of all the projects proposed to be taken up and the irrigation benefits expected from them, State-wise :—

Table 8.3
Cost and benefit of new irrigation and multi-purpose schemes proposed in drought affected areas

State	Benefits (000 hectares)	Cost (Rs. million)
1	2	3
Andhra Pradesh	2,077	4,736.7
Gujarat	232	507.5
Haryana	151	261.2
Madhya Pradesh	235	1,312.2
Maharashtra	758	2,252.1
Mysore	1,292	3,889.5
Rajasthan	333	578.5
Tamil Nadu	17	105.5

8.50 Among the precarious drought affected districts which stand to gain most from the new works, are Mahbubnagar and Kurnool in Andhra Pradesh; Khargon in Madhya Pradesh; Poona, Ahmednagar, Sangli, Satara and Sholapur in Maharashtra; Chitradurga, Gulbarga, Raichur, Bellary and Bijapur in Mysore; Gurgaon and Mohindergarh in Haryana; and Banswara in Rajasthan. In view of the limited natural resources of most of the drought areas and the need for developing irrigation there, we recommend that new works which are technically feasible should be given priority in implementation.

Scope for transporting water from outside

8.51 Surface water sources in some drought areas are limited. For example, in the chronic drought affected areas of Rajasthan; there are practically no sources of surface irrigation. The situation is no better in the Saurashtra and Kutch areas of Gujarat, and in the drought areas of Madhya Pradesh. The prospects of groundwater development are also very limited in most of these areas. It would be worthwhile, therefore, to explore the possibilities of transporting water from outside. The problem bristles with difficulties, as massive volumes of water will have to be diverted from one basin to another, and will probably involve costly storage works, engineering structures, lifts, etc. Inter-basin links are, however, not new to this country. They have been tried on a number of projects and have been found effective. The Periyar Project in Tamil Nadu is one such project. The Rajasthan Canal and the Parambikulam Aliyar Project are two important diversion works at present under

construction. Haryana has two such schemes under implementation, viz., the Gurgaon Canal Project and the Jui Canal Scheme. The former receives flood waters from the Yamuna and perennial flows for nine months from the Ravi and the Beas for the benefit of areas in Gurgaon district east of the Aravalli hills, and parts of Rajasthan.

8.52 Some possibilities of such inter-basin diversions have been suggested by the State Governments. They are indicated below:

Andhra Pradesh

Diversion of water from the Krishna river by taking up Nagarjunasagar Stage II and the Somasila Project.

Gujarat

The Narmada and Kadana High-level Canal to extend irrigation to extensive drought affected areas in north Gujarat, Saurashtra and Kutch, and in the Barmer district of Rajasthan along the international border. The scheme proposes to utilise the waters of the Narmada and Mahi rivers. It is expected to extend irrigation to more than half the drought areas in Gujarat, if implemented as envisaged by the Khosla Committee.

Haryana

Three lift schemes have been proposed to irrigate the drought areas of Rohtak, Hissar, Gurgaon and Mohindergarh. They are the Sohna Plateau Stage I (Gurgaon), Nahar Salhawas Lift Irrigation Scheme and Dadri Lift Irrigation Scheme. These schemes intend to utilise the flood flows of the Yamuna and also the supplies available in the local drains. The State has also claimed 5,920 m. cu. m. of the Ravi-Beas waters to firm up and extend irrigation by existing works.

8.53 Besides the above, the Commission feels that the feasibility of the following schemes may also be investigated:

(1) *Andhra Pradesh*: Diversion of some portion of the waters of the Krishna to the Rayalaseema area from the Srisailam reservoir. The less dependable flows of the Krishna may also be diverted into this region for recharging groundwater aquifers.

(2) *Haryana and Rajasthan*: The Yamuna Pumping Storage and Groundwater Recharge Scheme for irrigation and groundwater recharging. The scheme would benefit parts of the Jhunjhunu and Churu districts in Rajasthan, and Mohindergarh and Hissar districts in Haryana.

Water harvesting techniques

8.54 In drought areas it is of the utmost importance that whatever little precipitation is received should be effectively utilised. Water supplies in these areas can thus be significantly augmented. Much of the rainfall in these areas is, at present, lost by evaporation, stream-flow and seepage. Increased yields in low rainfall areas can substantially increase the potential for irrigation.

8.55 The technology of water-harvesting consists of collecting and storing water from land treated so as to increase the run-off of rainfall. Run-off from catchments can be utilised to a greater extent by building contour ditches to collect hillside flows. It can be increased by modifying vegetation, as also by treating the soil surface with impermeable sheets, etc. When large areas of low-cost land are available, land clearing and land shaping can greatly increase the utilisable water and may provide the most economical method of water harvesting. Cultivation techniques, like growing crops in strips, and leaving areas of suitable size and shape on both sides of these strips to facilitate the flow of rain water to them have also been tried and found effective. The new water-harvesting techniques offer good possibilities for augmenting water availability in rain-fed areas. Research efforts currently in progress on the subject need to be strengthened and extended to cover all important soil-regions in the country. An extension programme should also be mounted to popularise these techniques.

Groundwater Investigations

8.56 The question of groundwater development has been discussed in detail in the State chapters. However, we observe that among the States affected, only Rajasthan, Haryana and Gujarat have been adequately covered by groundwater surveys. In other States, such as Madhya Pradesh, Maharashtra, Mysore, Andhra Pradesh and Tamil Nadu, most of the districts which fall in the drought zone have either remained unsurveyed or have been only partly surveyed. There is, of late, a greater awareness of the need to organise such surveys, and almost all the States have taken steps to do so. Besides, the Geological Survey of India (GSI) and the Central Ground Water Board (CGWB) are also continuing their work in selected areas. Since reliable information about the irrigation potential in different areas is at present lacking, we would urge a comprehensive assessment of the potential from surface and groundwater sources in the drought affected areas.

District-Level Agency for Minor Irrigation Development

8.57 In the course of our tours we came across a number of instances where minor irrigation works, particularly groundwater schemes like wells and tubewells, had not made adequate progress in drought affected areas, mainly because technical guidance and assistance in constructing wells and tubewells were not available to the farmers. At some of the meetings we attended, a suggestion was made that there should be a district-level agency to advise and assist the farmers in construction of wells and tubewells. We have given careful consideration to this suggestion and feel that a district-level agency headed by a competent engineer to advise farmers in the selection of sites for wells and construction of tubewells, and also to assist them in blasting, boring and deepening wells would be useful. This agency should have sufficient equipment and machinery, particularly rigs, to help the farmers. The equipment can be hired out to the farmers or the work of drilling, blasting, boring etc, could be carried out on a cost basis. In some States, District Agro-Industries Corporations are providing such services but in others, particularly in drought affected areas where such corporations have not been set up, we suggest the setting up of a district-level agency on the above lines.

Irrigation Policy for Drought Areas

8.58 The general aspects of irrigation policy in low rainfall areas have already been discussed in Chapter VI. Because of the wide range of situations obtaining in drought areas, the basic elements of policy will have to be adapted to the general characteristics of the more homogeneous climatic regions such as the arid and semi-arid zones with which these areas have been identified earlier. The main ingredients of a suitable irrigation policy for the arid and semi-arid areas are indicated below :—

(1) *Chronic Drought Areas*

8.59 For areas such as the western parts of Rajasthan under desert conditions, and Kutch and parts of Rayalaseema situated in the arid zone, the main policy should be as follows:

(a) first priority to be given to the provision of drinking water;
(b) the next priority may be given to industries in view of their small requirements and income-generating potential;
(c) after meeting domestic and industrial requirements, the balance of water to be used in growing such crops, grass or trees or for animal husbandry, to maximise the income per unit of water;

for instance, pasture development in the Banni area of Gujarat and the growing of grass and fodder crops in parts of west Rajasthan;

(d) such varieties of crops to be selected as would make the most economic use of water;

(e) such methods of irrigation (e.g. trickler, sprinkler, etc.) to be adopted as would minimise the use of water and restrict wastage; the lining of canals and distributaries to minimise water losses; and

(f) dry farming methods including conservation technology to be popularised so as to conserve as much natural moisture as possible.

(2) *Drought Areas*

8.60 The main policy for drought areas should be the conjunctive use of water from rainfall, surface and groundwater sources, and the introduction of a crop pattern which would provide optimum protection from drought and at the same time ensure a reasonable and reliable income per hectare. Irrigation works in the area should aim at giving 'protective' irrigation to as wide an area as possible, if necessary, by introducing the principle of localisation.

8.61 There cannot be, however, any rigidity in the application of these principles; the best results will be achieved when they are judiciously combined and applied to suit the requirements of particular areas.

Criteria for Irrigation Works in Drought Areas

8.62 In Chapter XI while discussing the financial criteria for sanctioning irrigation works we have recommended a benefit-cost ratio of 1.5 for irrigation projects in general. However, the extension of irrigation to low rainfall areas has generally proved to be more costly because of the need to construct storage works, to spread irrigation over large areas, to undertake lining of channels, etc. This being so, if rigorous tests of productivity are applied, it may not be possible to take up as many new schemes as are required in these areas. The likely expenditure on famine relief also needs to be taken into account because the introduction of irrigation would reduce, if not eliminate, such expenditure. We have observed that only a few States like Gujarat and Maharashtra have given consideration to the special needs of drought areas while deciding criteria for financing irrigation projects. The Gujarat Government has relaxed the benefit-cost ratio in respect of major and medium schemes in drought and other backward regions up to

unity. The Maharashtra Government allows such relaxation only in respect of irrigation schemes costing less than Rs. 30 million. Both these Governments have fixed more liberal yard-sticks in respect of minor works like storage tanks, percolation tanks, check dams etc. The Gujarat Government has gone further and has removed all cost restrictions on medium- or minor-irrigation schemes in scarcity areas, under certain conditions. We support a liberal policy in respect of irrigation works in drought areas and recommend that the benefit-cost ratio in respect of major and medium works in those areas may be relaxed up to unity. It is also necessary to provide special loans at concessional rates to the States to facilitate the construction of irrigation works in the drought areas. This matter will be dealt with in Chapter XI.

CHAPTER IX

IMPROVEMENTS TO EXISTING IRRIGATION SYSTEMS

Many of the irrigation systems in the country date back to the 19th century or earlier and need to be remodelled in order to bring them up-to-date and to increase their effectiveness. Systems such as the Eastern and Western Yamuna Canals which date back to 1780 and which were brought again into regular use by the British in 1820, after falling into disrepair, the Cauvery Delta System for which Arthur Cotton constructed the Upper Anicut in 1836, the Upper Ganga Canal, the Upper Bari Doab Canal and the Godavari Delta System, are all fine examples of irrigation engineering which, in the context of the present advancements in agriculture and irrigation technology, need improvement.

9.2 Modern agriculture is exacting in its demands for water, and the high-yielding varieties call for irrigation regimes which many of these systems in their present shape cannot sustain. Their usefulness is limited by structural handicaps such as out-moded headworks, the absence of suitable silt excluding devices, and unsatisfactory arrangements for cross drainage. These handicaps are reinforced by other factors such as faulty irrigation management and poor drainage and distribution.

9.3 The irrigation systems of the country fall broadly into two groups. The first consists of those whose supplies of water are derived solely from diversion works, on rivers which may be either snowfed or purely rainfed, as in Central and Peninsular India. The second group consists of those whose supplies are derived from storage reservoirs. Each system suffers from its own peculiar inadequacies which call for specific remedies, which will be discussed later in this chapter.

9.4 Diversion works merely raise the level of water in the river to permit its diversion into the canal system, whose capacity for irrigation, therefore, necessarily varies with the volume of the natural flow in the river. Problems arise when the canal flows fall below the level required to meet, the needs of the commanded area. While the irrigation systems

in the Indo-Gangetic plains run short of supplies in the winter, those in Central and Peninsular India, face shortages in summer after having carried substantial flows during the monsoon.

9.5 The design of the canals, and irrigation management as practised in some of these systems, also have much to do with the problem of inadequacy. Where canals run through the flat alluvial plains of northern India, the objective is to do extensive irrigation so that the canal system covers as much territory as possible. The area for which water is sufficient, may be only a portion of the culturable commanded area, and each farmer is entitled to a share of water which is in the same proportion as his area bears to the total area. Under the Warabandi or 'turn' system under an outlet, each farmer in turn gets irrigation water for a certain period in the week. He has the freedom to grow the crops of his choice, to develop his own cropping pattern and to determine the area which he wishes to irrigate in each season. He gambles with the rain and sows a large area. However, if the rains fail, he tries to irrigate as much of the area as possible with his share of canal water. In the rabi season, this share is scanty because of the general inadequacy which we have mentioned above. Irrigation under these conditions tends to be thinly spread out and inadequate.

9.6 Where the requirements of water for a crop like rice have to be adequately met, particularly at critical periods such as transplantation and flowering, inadequacies arise when the discharge in the canals during these critical periods is insufficient. Inadequacies can also arise, particularly in the tail-reaches of systems, if the duties have been incorrectly fixed or if there is unauthorised irrigation in the upper reaches of the canal, or where canal supplies into the various off-takes have not been properly regulated.

9.7 In run-of-the-river systems like the Sarda Canal System, not only do shortages occur during the rabi season but they may be experienced even towards the close of the kharif season. The late rice crop, for example, may need a watering early in October which may be difficult to provide if a poor monsoon has led to a drop in canal supplies. The pre-sowing (palewa) irrigation for wheat may also be affected, particularly when there is a competing demand for water by late rice and sugarcane.

9.8 In systems depending upon storage reservoirs, inadequacies arise when the monsoon is weak, or when it is delayed. The effect of the inadequacies is enhanced, if a reservoir is being silted up at a more rapid rate than was anticipated.

9.9 In order to highlight the problem of inadequacies, we propose in the succeeding paragraphs to deal with a few representative systems such as the Sarda Canal System, the Lower Ganga Canal, the Eastern and Western Yamuna Canals and the Godavari Delta System.

The Sarda Canal System

9.10 The Sarda Canal System, which is a typical diversion system, has a culturable commanded area of 2.23 million hectares. The area under irrigation (1967–68) was 51,400 hectares of perennials, 0.25 million hectares of kharif and 0.41 million hectares of rabi, i.e., a total of 0.71 million hectares. This indicates rather low intensity of 32 per cent, and even this is not uniformly obtained throughout the system. From 42 per cent in the upper reaches it drops to 19 per cent in the lower reaches. The inadequacies of the system affect the growing of wheat and other rabi crops. Table 9.1 shows the average flows in the Sarda river and the average discharge diverted into the Sarda Canal, in different months of the year.

9.11 Water is diverted from the Sarda river by a barrage at Banbassa (district Nainital). The canal takes off from the right bank of the river and was originally designed to carry a discharge of 230 cumecs. Subsequently, it was remodelled to carry a maximum discharge of 385 cumecs at the head. However, since 60 cumecs are passed into silt ejectors, the discharge available for irrigation is only 325 cumecs.

9.12 While the canal draws on an average as much as 290 cumecs in August, the discharge drops by nearly 50 per cent to 146 cumecs in March. The distributaries and branch canals have then to be run by rotation depending on the quantity of water available in the main canal and the nature of crops. A distributary may, for example, be opened for one week in a period of three weeks or continuously for two weeks in a period of six weeks and so on.

9.13 Though the time-table is prepared with care, it has of necessity to be based upon estimates of what the river will carry in the ensuing weeks. If these estimates turn out to be incorrect, the whole system of rotation is upset. Even if all goes well, the water allotted to each farmer may not be timely or adequate.

9.14 At present, generally speaking, only the traditional varieties of wheat are sown in the area under the Sarda command. However, after inadequacies are removed, it should be possible to introduce the

new high-yielding varieties. According to the Indian Agricultural Research Institute, for a good crop of traditional wheat in the Lucknow area, sowing should generally commence by the middle of October and should not be delayed beyond the first week of November. The first or 'kor' irrigation is required four weeks after sowing. The second irrigation is required at the tillering stage after a lapse of another four weeks, and the third, twenty days later at the flowering stage. Table 9.2 states the days over which each irrigation should be spread. Table 9.3 shows the areas irrigated by the Sarda Canal in the rabi season between the years 1960–61 and 1967–68.

9.15 Canal outlets are normally designed to irrigate the rabi area once in three to four weeks. This would be quite satisfactory if the system were to run continuously. However, in practice, this is not what happens. Since the distributary cannot be kept open continuously, each farmer, as we have explained, has to await his turn. In consequence, the critical 'kor' irrigation cannot be given by some farmers to their fields till several weeks after it has become due. As a result, a substantial area is denied water at the proper time and there is a drop in yields.

9.16 On the basis of the Technical Memorandum of Uttar Pradesh Irrigation Department, an allowance for the depth of water in the field comes to 9.8 cm. and 12.1 cm. respectively for wheat and sugarcane irrigation.* Allowing for a loss of 45 per cent from the head-regulator to the field, the depth of water needed at the head-regulator for each irrigation of wheat and sugarcane would be 17.8 cm. and 22.0 cm. respectively. On the other hand experiments indicate that the best results for wheat can be achieved by giving an irrigation of 7.6 cm. in the field, at 4 week intervals. For sugarcane, the depth would be 12.7 cm. Thus the depth of the water needed at the head-regulator for each irrigation of wheat and sugarcane would be 14.0 cm. and 22.9 cm. respectively. We have adopted these latter figures for our study.

9.17 Table 9.4 shows the average monthly rainfall in Lucknow district from October to March during the years 1960 to 1967. The rainfall was negligible throughout the seven year period in the month of November. It was negligible for five years out of seven in December and for four years out of seven in January. For these reasons we have ignored the incidence of rainfall in our calculations. Table 9.5 shows the quantity of water needed for each watering of sugarcane and other rabi crops

*These figures have been adjusted on the basis of the Technical Memorandum which mentions 13.3 cm. for wheat and 16.5 cm. for sugarcane at the outlet.

Table 9.1

Sarda Canal

Statement of river supplies available and quantities diverted

(Average discharges in Cumecs)

Month	1960–61	1961–62	1962–63	1963–64	1964–65	1965–66	1966–67	1967–68	Total	Average
1	2	3	4	5	6	7	8	9	10	11
June	$\frac{297}{216}$	$\frac{577}{267}$	$\frac{628}{269}$	$\frac{463}{482}$	$\frac{355}{254}$	$\frac{409}{293}$	$\frac{539}{250}$	$\frac{342}{288}$	$\frac{3610}{2127}$	$\frac{451}{266}$
July	$\frac{1595}{109}$	$\frac{1489}{245}$	$\frac{1405}{262}$	$\frac{1574}{403}$	$\frac{1764}{278}$	$\frac{1052}{313}$	$\frac{1209}{315}$	$\frac{1584}{323}$	$\frac{11672}{2248}$	$\frac{1459}{281}$
August	$\frac{1141}{205}$	$\frac{3020}{218}$	$\frac{2662}{279}$	$\frac{2662}{293}$	$\frac{2387}{310}$	$\frac{1236}{327}$	$\frac{2662}{334}$	$\frac{2640}{344}$	$\frac{18410}{2310}$	$\frac{2301}{289}$
September	$\frac{1454}{205}$	$\frac{1508}{238}$	$\frac{1880}{264}$	$\frac{1984}{301}$	$\frac{2164}{304}$	$\frac{636}{337}$	$\frac{930}{345}$	$\frac{1399}{315}$	$\frac{11955}{2309}$	$\frac{1494}{289}$
October	$\frac{631}{190}$	$\frac{1109}{233}$	$\frac{623}{286}$	$\frac{441}{308}$	$\frac{620}{312}$	$\frac{286}{282}$	$\frac{325}{307}$	$\frac{402}{340}$	$\frac{4437}{2258}$	$\frac{555}{282}$
November	$\frac{284}{246}$	$\frac{428}{279}$	$\frac{317}{286}$	$\frac{308}{276}$	$\frac{294}{280}$	$\frac{201}{200}$	$\frac{212}{211}$	$\frac{232}{239}$	$\frac{2276}{2017}$	$\frac{284}{252}$
December	$\frac{211}{213}$	$\frac{262}{266}$	$\frac{223}{222}$	$\frac{220}{205}$	$\frac{207}{207}$	$\frac{150}{150}$	$\frac{163}{163}$	$\frac{191}{190}$	$\frac{1617}{1616}$	$\frac{202}{202}$

January	187/183	230/206	170/169	166/163	165/165	125/121	130/131	166/166	1339/1304	167/163
February	271/176	201/196	145/140	140/140	173/147	118/116	114/112	152/153	1314/1180	164/148
March	186/189	223/203	171/170	140/142	179/77	110/109	112/110	163/163	1284/1163	161/145
April	216/212	193/218	194/194	179/178	218/217	117/118	128/128	177/178	1422/1443	178/180
May	258/251	253/246	279/252	215/217	236/230	69/182	177/155	234/231	1721/1764	215/221

Note 1 : Numerator indicates supplies available.
Denominator indicates supplies diverted.

Note 2 : There are discrepancies; for example—more supplies are diverted than available in a few cases—and less supply is drawn than is available and needed in others. As reasons are not forthcoming for these and as they do not affect the calculations in this study, they have been allowed to remain in the table.

Table 9.2

Statement showing desirable irrigation schedule for traditional varieties of wheat (Lucknow area)

Description	Period	Remarks
1	2	3
Sowing which is expected to be spread over three weeks.	15th October–4th November	Palewa irrigation is done prior to sowing.
Kor irrigation commencing four weeks after sowing.	12th November–2nd December	Just like the period of sowing, irrigation is also spread over a period of three weeks over the area.
Irrigation at tillering stage—four weeks after Kor.	10th December–30th December	–do–
Irrigation at flowering stage—20 days afterwards.	31st December–20th January	–do–

Note: The above information has been collected from the experts at the IARI—Delhi.

Table 9.3

Area irrigated by the Sarda Canal in the rabi season

(Hectares)

Year	Annual Sugarcane	Rabi			Total of sugarcane and rabi
		Wheat	Others	Total	
1	2	3	4	5	6
1960–61	99,357	153,063	123,385	276,448	375,805
1961–62	93,580	113,986	94,678	208,664	302,244
1962–63	80,609	184,058	163,923	347,981	428,590
1963–64	83,766	204,392	193,934	398,326	482,092
1964–65	103,478	177,438	162,708	340,146	443,624
1965–66	97,826	220,962	159,788	380,750	478,576
1966–67	63,550	265,230	225,765	490,995	554,545
1967–68	51,712	222,802	186,106	408,908	460,620
Total	417,391	1,009,652	866,459	1,876,111	2,293,502
Average	83,478	201,931	173,292	375,223	458,701

Note: The figures for the years 1960–61, 1961–62 and 1966–67 have been excluded for striking total and average.

Table 9.4
Monthly rainfall in mm. for Lucknow (Uttar Pradesh)

Year	October	November	December	January	February	March
1	2	3	4	5	6	7
1960–61	287.5	0	0	35.8	26.2	0
1961–62	209.3	0	0	35.9	8.9	0
1962–63	0	0	0	18.4	0.2	1.8
1963–64	1.4	10.4	0	0	2.0	0
1964–65	39.4	0	26.2	0.2	0	6.8
1965–66	84.6	0	0	5.7	0	0
1966–67	17.9	5.3	13.0	0	0	16.2

Table 9.5
Statement showing the quantity of water needed for each watering

Nature of crop	Average extent (hectares)	Depth of water for each wetting at head of canal (cm.)	Quantity of water needed at head of canal (m.cu.m.)
1	2	3	4
Sugarcane	83,477	23	191
Wheat	201,928	14	524
Other rabi crops	173,289	14	
		Total :	715

for the average areas shown in Table 9.3. On this basis the total quantity of water needed for each watering would amount to about 71,500 hectare-metres.

9.18 Table 9.6 shows the quantity of water let out at the canal head during the periods indicated in it, compared to the quantity of water actually needed for each watering during these periods. The table brings out the inadequacy of irrigation supplies. It is clear that under such conditions, high-yielding varieties of wheat would be difficult to grow over an extensive area. Under the tight system of rosters, the precise irrigation schedule necessary for growing high-yielding varieties cannot be maintained.

Table 9.6
Statement comparing irrigation needs with availability

Period of irrigation	Requirement of water (m.cu.m.)	Water diverted into the canal (m.cu.m.)	Remarks
1	2	3	4
12th November–2nd December	715	452	The figures in col. 4 have been derived from the average dis-
		124*	charges given in Table 9.1
10th December–30th December	715	371	*From 3rd to 9th December a supply of 124 m.cu.m. is
31st December–20th January	715	302	available which is considered in the total.
Total	2,145	1,249	

Note : The assistance given by Sarda Sagar has not been taken into account but it is understood that it could not have given an assistance of more than 247 m.cu.m. for all the three periods (noted above) put together. The assistance of Nanak Sagar came into effect only from 1969.

The Lower Ganga Canal System

9.19 The various inadequacies to which we have drawn attention in relation to the supply of water from the Sarda Canal during the rabi season in Uttar Pradesh also prevail in the Lower Ganga Canal System.

9.20 The pattern of roster in force at the Fatehpur Branch of the Lower Ganga Canal during the rabi season brings out the fact that unless the adequacy of the system is improved, timely irrigation during this season can be available only for limited areas.

The roster is as follows:

Open	...	Three weeks
Close	...	Two weeks
Open	...	Two weeks
Close	...	Three weeks
Open	...	One week

Thus in a period of eleven weeks, the branch is open for six weeks. Although the outlets of the branch are designed for a six week period, the 'kor' irrigation is spread over eleven weeks, which means that all areas cannot expect to receive timely irrigation.

The Eastern & Western Yamuna Canals

9.21 Inadequacies during the rabi and early kharif seasons are also felt in the commands of the Eastern and Western Yamuna Canals. The alignment and the crest level of the Tajewala Weir across the Yamuna, are such that the requisite discharge cannot be diverted into the Eastern Yamuna Canal. A temporary obstruction, which is washed away with every flood in the river has to be put across the river to hold up the water so that it can flow into the canal. It has been reported to us, that even though the full authorised discharge into the Eastern Yamuna Canal is 85 cumecs at the head, the maximum which it had drawn in the kharif season of 1970 was only 67 cumecs or 80 per cent of its capacity. Shingle is drawn into the canal and deposited immediately below the head-regulator. These shingle deposits have to be constantly cleared. A scheme to replace the weir has been under consideration for quite some time, but action has been held up for want of an agreement between the Haryana and Uttar Pradesh Governments.

9.22 We have been informed that there is a proposal to construct a new barrage about 3 km. above the present Tajewala Weir. The project has already been investigated, and we would recommend that the construction of the barrage be taken up soon.

Godavari Delta System

9.23 We have so far dealt with the inadequacies of water during the rabi season, but the cultivation of rice under irrigated conditions is also affected by inadequacies in the irrigation systems. Rice, which is grown over 41.8 per cent (1967–68)* of the irrigated area of the country, and consumes 45 per cent of the irrigation water, is essentially a kharif crop and the effects of inadequacies in supply are felt most acutely during transplantation. In diversion schemes from rivers not fed by the melting snows, supplies may be low if there is a delay in the onset of the monsoon, or if the monsoon is weak. This delays transplantation and results in lower yields from season-bound strains. The earlier in the season that transplantation is done the better are the yields for the traditional varieties.

9.24 Apart from the difficulty caused by a delay in the onset of the rains, there may be problems of submergence in low-lying areas during heavy rains, and if the crop has not grown sufficiently high by then, it may be damaged by prolonged submergence.

**Source*: Directorate of Economics & Statistics, Government of India.

9.25 In the Godavari Delta System which depends on run-of-the-river supplies, the canals are opened in the Godavari central delta on the 15th of May and in the eastern and western deltas on the first of June. The supply required for rice at the head of the delta at a duty of 1,000 hectares per cumec is 409 cumecs. The discharge* available in the Godavari at the head of the delta at Dowlaishwaram Anicut in June is as follows:

1st to 10th June	...	135 Cumecs
11th to 20th June	...	153 ,,
21st to 30th June	...	322 ,,

9.26 Supplies in June are inadequate and the position improves only after the beginning of July. As a result, transplantation is sometimes delayed till the middle of August and even beyond, whereas farmers are anxious to complete the transplantation of rice by the middle of July.

9.27 The Godavari Delta also raises a second crop of rice which is transplanted by about the end of January to be harvested by the end of April. As water is available for only about one-third of the area, a triennial rotation is adopted and every year a limited area is opened. However, run-of-the-river irrigation supplies vary from year to year and might also suddenly dwindle in the latter part of the season so as to cause serious damage to the crop.

9.28 The average discharge** at the Dowlaishwaram Anicut taken over a period of 40 years for 10-day periods from January to April clearly show how the supplies drop later in the season.

January	1–10	...	196 cumecs
	11–20	...	194 ,,
	21–31	...	191 ,,
February	1–10	...	186 ,,
	11–20	...	170 ,,
	21–28 or 29	...	169 ,,
March	1–10	...	159 ,,
	11–20	...	146 ,,
	21–31	...	134 ,,

**Source* : Report on a comprehensive project for agricultural development through utilisation of ground water in the Krishna-Godavari Deltas and the adjoining upland areas: Govt. of Andhra Pradesh—1968.

***Source* : Report on a comprehensive project for agricultural development through utilisation of ground water in the Krishna-Godavari Deltas and the adjoining upland areas: Govt. of Andhra Pradesh—1968.

April	1–10	...	123	,,
	11–20	...	111	,,
	21–30	...	102	,,

Measures for meeting inadequacies

9.29 Effective methods of meeting inadequacies on the existing run-of-the-river systems are : by the creation of storage reservoirs higher up the river, by the transfer of water from another basin or by the use of groundwater. Table 9.1 to which we have already drawn attention, illustrates the fact that in the Sarda river, as in other rivers of India, the maximum discharge is during the monsoon months. It is logical, therefore, to hold up the excess water during these months for release later on in the season.

9.30 The Uttar Pradesh Government has constructed a reservoir known as the Sarda Sagar to augment the supply of water in the Sarda System. This has been formed by constructing an embankment around a natural depression lying between the main Sarda Canal, and the river to store excess monsoon supplies. During the kharif season it is filled up by surplus canal water which is then made use of during the rabi. The Sarda Sagar provides the Sarda Canal System with an additional 0.05 million hectare metres of water.

9.31 The 'Project Assist' which is under construction, will transfer 368 cumecs from the Ghagra and another 28 cumecs from the Sarda into the system. In addition, the existing Dalmau Pumping Scheme on the Ganga and three other pumping schemes drawing water from the Ganga and the Gomati will ultimately supply an additional 57 cumecs. The intensity in the lower regions of the system will be raised from 32 per cent to 70 per cent when the schemes have been completed. In addition, 25 per cent of the rabi area will be able to grow high-yielding varieties of crops.

9.32 The inadequacies resulting from the silting up of the Sarda Canal have been solved, to a large extent, with the construction of a silt ejector, a furlong below the head-regulator. As a result, the canal has been able to draw an additional 57 cumecs.

9.33 We suggest that groundwater in the canal command should be exploited

(a) for meeting inadequacies;
(b) for further extending irrigation; and

(c) to minimise the danger of waterlogging which might arise with increased irrigation intensities in the area.

9.34 A dam at Pancheshwar, on the Sarda, will store water during the monsoon period and will not only mitigate the present inadequacies during the rabi period but will help to extend irrigation to further areas, both during the kharif and rabi seasons. According to preliminary proposals formulated by the Uttar Pradesh Government, the Pancheshwar Project, on completion, will provide irrigation to an additional 0.8 million hectares. We recommend that this project should be taken up at an early date.

9.35 Rivers like the Mahanadi, Narmada and Godavari carry about 93 per cent of their annual run-off during the monsoon months, and high floods during the period are not uncommon. In the circumstances, it is logical to hold up the excess water which is collected during the monsoon months for release later on in the season. This has already been done on many rivers in the country.

9.36 The Khadakvasla Dam on the Mutha river which was constructed in the 1870s was the earliest of such storages. It was built to store the water of the Mutha river and to release it for irrigation through the Mutha Right and Left Bank Channels.

9.37 Besides benefiting new areas, storage works improve the quality of irrigation in run-of-the-river schemes. The Mettur Dam on the Cauvery is a case in point. Before the dam was constructed in 1930, the Cauvery Delta was served by a typical run-of-the-river scheme, which carried adequate supplies only after the onset of the monsoon. Whenever there was a delay in the onset of the rains or a break in the monsoon, agriculture in the delta areas suffered. These difficulties have been overcome with the construction of the Mettur reservoir which now releases the right amount of water at the right time to sustain a stable agriculture in the delta area.

9.38 Similarly, the Krishna Delta System in Andhra Pradesh, the Mahanadi Canal System in Madhya Pradesh and the Mahanadi Delta System in Orissa have all benefited from reservoirs in the upper reaches of the rivers concerned.

9.39 The Mahi Right Bank Canal on the river Mahi, and the Kakrapara Canal on the river Tapi in Gujarat, which are run-of-the-river schemes, suffer from the limitations which we have described, and are

bound to benefit from the construction of the Kadana Dam across the Mahi and the Ukai Dam across the Tapi. The construction of reservoirs on the Godavari would make it possible for the Godavari Delta System to receive adequate supplies from the beginning of the season. Assured irrigation would also to provided in areas localised for a second crop.

9.40 Because Himalayan rivers carry sizeable flows even after the monsoon, it was not till recently that serious attention was paid to the need for storage reservoirs. The Bhakra Dam across the Sutlej was the first such major storage scheme and since then others, like the Pong Dam on the Beas and the Ramganga Dam in Uttar Pradesh have been planned.

9.41 We recommend that wherever it is feasible, storage works should be constructed to meet inadequacies in existing run-of-the-river schemes.

9.42 In some cases it may be possible to divert supplies from an adjacent basin where there is a surplus. We have already mentioned 'Project Assist' under which the Sarda will get water from the Ghagra. Such possibilities exist elsewhere too. The Western Yamuna Canal, for instance, is expected to receive supplies from the Ravi-Beas-Sutlej complex. It has already received 54 cumecs by the transfer of the Sirsa Branch and the Hissar major distributary to the neighbouring Bhakra Canal System. The possibility of diverting surplus water from the Godavari to the adjacent Krishna and Penner basins is worth investigation.

9.43 We find that when new storage reservoirs, or diversions from one basin to another are proposed, the tendency, at present, is to treat these as separate projects aimed at bringing new areas under irrigation. The traditional duties for the supply of water are followed both in the existing systems and in the new areas. We are of the opinion that the proper approach would be to examine in detail the short-comings present in the existing areas and to assess the inadequacy of supplies in them. The removal of inadequacies should be the first charge on additional supplies secured either from storage works or through diversion from another basin.

9.44 One important method of overcoming the inadequacy of an irrigation system is to promote the use of groundwater. 34 per cent (1967–68) of the irrigated area in the country is accounted for by irrigation from wells and tube-wells. Many of these lie in the command areas of canal systems.

9.45 We recommend that wherever groundwater is available in the command areas of an existing system, farmers should be encouraged to sink wells or tube-wells to overcome inadequacies in supply from the canals and to add to the irrigated area. They should be provided with financial assistance, technical guidance and power connections. We were glad to observe, during our tours, that these matters are already receiving the attention of the States.

9.46 There are some special cases of inadequacy which call for more specific remedial measures. In Chapter XIV, we have referred to the heavy silting in the Nizamsagar reservoir and the steps to be taken for restoring the storage capacity and preventing further silting up of the reservoir. The Bhavanisagar reservoir is unable to supply water, in full, to the areas under its command, because farmers have begun to grow rice, whereas the reservoir was primarily designed to irrigate crops such as millets and cotton with low water requirements. The Tamil Nadu Government has recently issued orders prohibiting the cultivation of rice as a second crop, and this measure is expected to improve the situation.

9.47 The Meshwa, Hathmati and Dantiwada reservoirs in Gujarat, and the Walayar reservoir in Kerala do not receive as much water from their catchments as was originally estimated, with the result that cultivated areas in the ayacuts of these systems experience shortages. The remedy lies in adjusting the cropping pattern, to suit the actual supplies distributed by the systems.

Deficiencies in Headworks

9.48 We have already referred to various short comings at the headworks of the Eastern Yamuna Canal. The headworks of some other systems also suffer from defects such as the absence of proper diversion works and silt excluding devices. Proper attention to these handicaps would go a long way towards improving the efficiency of such systems.

9.49 We would, therefore, recommend that a rapid survey should be made of the headworks of existing systems all over the country to assess the extent to which they need to be remodelled. We would further recommend that priority be given to improving these headworks. In particular, permanent diversion weirs should be constructed wherever water is at present being diverted by means of temporary diversion works which have to be replaced every season. In discussing the Tajewala weir we have drawn attention to this point.

9.50 Many diversion weirs are fitted with crest shutters. The Bhimgoda weir across the Ganga at the head of the Upper Ganga Canal, the Rudri weir at the head of the Mahanadi Canal System and the Dowleishwaram Anicut (weir) at the head of the Godavari Delta System are examples. Whenever the water level rises, these shutters fall, either automatically or by operations which cause them to fall and allow the floods to pass. But after the floods pass, the shutters have to be lifted by manual labour. (In the Dowleishwaram Anicut, there is a mechanical plough for the purpose). This cannot be done till the water over the weir recedes sufficiently, to allow the shutters to be put back in position to build up the water level. This means delay, which may last for only a few days, but might be sufficient to affect the irrigation of crops.

Supplies into the Krishna Delta System have improved, and larger areas than before are being commanded after the construction of the Prakasam Barrage in place of the Vijayawada Anicut, which had started showing signs of failure after having been in use for about a century. Sanction has recently been given for the construction of a barrage in lieu of the present Dowleishwaram Anicut which is also more than a century old. It is desirable that this work should be completed early. The Okhla weir near Delhi is an old one with no proper energy dissipating devices and it has been decided to replace it by a barrage.

The Commission recommends that old weirs should be replaced by barrages, which not only make operation at the headworks easy but also improve the supply and add to irrigated area, besides keeping flood levels down upstream of the structure.

We also recommend that in weirs or barrages, or canals, shingle or silt excluding devices should be installed wherever these are required. These devices would improve supplies in the canal, and reduce expenditure on the clearance of shingle or silt.

Shortcomings in distribution systems

9.51 Irrigation supplies can be dislocated by a variety of factors such as inflowing drainage, absence of adequate control works, troublesome embankment reaches, uncontrolled seepage, and weeds. Some of the steps necessary for dealing with these problems are discussed below.

Drainage inlets

9.52 In many of the older canal systems, local streams, are permitted to fall into the canals. In spite of the fact that suitable escapes are provided, the regulation of water becomes difficult during the rainy season. Sudden heavy flows and debris floating in the drains pose a danger to control works on the canal.

9.53 The experience gained on the Upper Ganga Canal in the early 30s illustrates the dangers of such a situation. The amount of debris brought in by inlets upstream of the power house at Bahadurabad, seven miles below the head-regulator of the Upper Ganga Canal, was so great that it piled up against the trashrack and could not be cleared with sufficient speed. An enormous pressure was built up against the trashrack, which ultimately gave way, sucking two men into the turbine pit. Thereafter, the debris passed through the turbine pit and over the regulating gate. It was fortunate that the trashrack collapsed, otherwise there would have been a breach in the canal upstream of the power-house which may well have led to an even greater disaster.

Drains enter the Vennar branch of the Cauvery Delta System and the escapes do not have adequate capacity. As a result, large quantities of water flow down the system breaching canal embankments and inundating low lying areas.

We recommend that as far as possible, drainage should be prevented from entering the canals and should be dealt with by suitable cross-drainage works.

Regulators and Escapes

9.54 In many canal systems the number of control structures is inadequate, so that the efficient control of water becomes difficult. Such arrangements as putting up temporary obstructions using the bridge openings to head up water, are far from satisfactory. On the long canals, a sufficiency of escapes is necessary so that in an emergency, excess water from the canal can be let out quickly. Of course, the escapes would have to be located on the basis of the importance of the canal and the availability of suitable escape points.

Embankments

9.55 Embankment reaches on a few canal systems are very vulnerable. Very often, these reaches are built by using local soils which are not always ideal. For example, embankments in the Grand Anicut Canal of the Cauvery-Mettur Project used to give continuous trouble at the height of the irrigation season, and cause severe dislocation to irrigation. The Chambal Main Canal in Madhya Pradesh failed at three places in 1968–69, with the result that supplies could not be resumed for the rest of the season. The problem in one reach of the Grand Anicut Canal has been overcome by the lining of the canal, and that in the Chambal Canal by the strengthening of the embankments. In addition, systematic patrolling of banks is being done. We would suggest that sign-posts

should be placed on the banks to indicate embankments of various heights, so that inspecting staff can be made aware of the areas needing attention.

9.56 Very often, in these systems only one bank is used for inspection purposes, with the result that the other bank is neglected. We would recommend that in the case of important canals, both banks should be made fit for inspection.

9.57 We have dealt with the lining of canals in Chapter VI and we recommend that in unlined canal systems, seepage losses in selected stretches should be systematically studied so that the priorities in lining can be laid down.

Another aspect of seepage losses which deserves study, is that where water is let down from a storage reservoir into the river to be picked up at a considerable distance below, for diversion into a canal system. Seepage losses in the river bed in these cases may be quite high and deserve to be assessed. In such cases, we would recommend the investigation of the possibility of carrying water through a lined canal instead of the river bed, in order to reduce seepage losses.

9.58 There may be other cases also, where lining is warranted, for example, in reaches where frequent breaches are caused because of the nature of embankment soil, and those with a profuse growth of weeds. Lining in such cases would minimise seepage losses, reduce recurring costs and provide better irrigation supplies.

9.59 The feasibility and the economics of lining should be carefully examined when canals are to be remodelled. Lining will reduce seepage losses and confer other benefits. When the Kurnool-Cuddapah Canal in Andhra Pradesh was remodelled and lined, irrigation became more stable.

Remodelling

9.60 Some of the older canal systems call for drastic remodelling to enable them to function efficiently. The Cauvery Delta System in Tamil Nadu is a case in point. After the construction of the Mettur Reservoir, this system was partially remodelled. However, a good deal remained to be done, and the Tamil Nadu Government has prepared a comprehensive scheme for remodelling and modernising the system. Its main features are :—

(i) Improving headworks to enable them to control floods;

(ii) De-silting, raising the banks and lining selective reaches of the major elements of the distribution system;
(iii) Construction of other control structures wherever necessary;
(iv) Bringing main channels to proper standards, constructing grade-walls and pipe sluices, providing water courses and supplementing the supply of water in irrigation-cum-drainage rivers;
(v) Improving the Lower Coleroon Anicut; and
(vi) Providing drainage relief.

After sepatate irrigation and drainage channels to each field have been provided, 0.12 million hectares of land will get the benefit of better water management practices. An integrated use of surface and ground-water will be made possible by the sinking of 5,000 filter points and 1,000 deep bore-wells. The latter will help farmers to raise seedling-nurseries in advance of the opening of the canals in the Mettur System. The filter-points will be sunk by the farmers themselves with the help of loans from Land Development Banks. It is expected that the scheme will permit the growing of a second irrigated crop over an additional area of 0.14 million hectares. It will also increase the yield per hectare. The additional production of paddy is expected to be of the order of 1.1 million tonnes.

9.61 Another case of remodelling relates to the old Kalingarayan channel which takes off from an anicut of the same name across the river Bhavani in Tamil Nadu. It illustrates the inadequacy of irrigation at the tail-end of a system with too many and oversized outlets. This canal which is about 92 km. in length, has as many as 769 outlets varying in diameter from 7.6 cm. to 30.5 cm. The main crop is rice, growing on an ayacut of 6.370 hectares. The full supply discharge into the channel is 16 cumecs. The heavy waste of water through oversized outlets and too many outlets is aggravated by the withdrawal of water from the channel by unauthorised pumping sets installed on its banks. These factors have combined to reduce the duty on the channel to 458 hectares per cumec for rice against the normal 858 to 1,000 hectares.

The remodelling scheme which has been proposed for this channel to increase its efficiency and to remove the inadequacies at the tail reaches, would involve the clubbing together of areas under adjoining outlets, and changes in the canal sections. The remodelling is expected to result in a considerable saving of water, and to provide stable irrigation throughout the system. The water saved may be used to irrigate fresh areas.

9.62 The Kalingarayan channel is only one of a number of old systems in the country which need to be remodelled and modernised. In some of such systems, rosters have to be resorted to, even on the distributaties,

since they are not capable of carrying their full authorised discharges. In such cases, distributaries have to run at low discharges, but for longer periods than would be necessary had they carried higher discharges. This entails greater seepage losses, and it would be worthwhile to remodel these distributaries to remedy defects.

9.63 Remodelling is also called for in the ayacuts of irrigation systems which have been altered or enlarged from time to time. In the process, temporary outlets have sometimes been added to the system to meet local difficulties. Channel sections might also have changed due to silting, erosion, cross-bunding of channels and the cutting of banks. All these factors have combined to reduce the hydraulic performance of the system. It seems desirable, therefore, that each system should be examined once every twenty or thirty years or so, and remodelled to ensure that irrigation water is economically used and equitably distributed. Records and maps of these systems should also be revised and brought up-to-date. The deficiencies in the system should be examined and listed and suitable proposals framed for remodelling.

Remodelling schemes should, inter alia, include:

(1) Measures for working the system with greater efficiency and minimum loss of water;
(2) Measures to supplement supplies by pumping water from neighbouring rivers or from sub-soil reservoirs and by transferring water from adjacent basins;
(3) Changes in cropping patterns;
(4) Measures to enlarge areas under irrigation and to increase the intensity of irrigation.

Drainage and Waterlogging

9.64 We have dealt with the problem of waterlogging and drainage in Chapter XIII. Here we would recommend that each of the major existing irrigation projects should be examined to discover deficiencies in them so that corrective measures may be applied.

Irrigation Management

9.65 Methods to convey water beyond the outlet and to utilise it in the field have changed very little over the years. Very often, water is conveyed through long, tortuous and badly maintained field channels, before being let into farmer's fields through cross-bunds and cuts. Culverts are generally not provided where village cart-tracks cross field channels, so that damage to channels is frequent. Inevitably, there is

loss of water. Field-to-field irrigation prevails in rice areas, which is not only wasteful of water, but results in over-irrigating fields near the outlets and under-irrigating fields at the tail-end reaches.

9.66 An example of what planned irrigation management can achieve is the experiment which we observed at Siddamalli village in the middle of the Cauvery Delta System. Here, 21 farmers have pooled the 162 hectares of land in their possession for being parcelled into rectangular plots of about 0.4 hectare each. Straight and narrow bunds have replaced the old zig-zag and oversized field bunds, and each field in individually irrigated and drained through straight and narrow channels. The wasteful and inefficient field-to-field irrigation which was previously practised has ceased. Proper embankments have also been raised along the drains and channels to prevent inundation.

9.67 At a cost of about Rs. 445 per hectare the experiment had increased the output of high-yielding rice by 0.6 tonne per hectare. The cropped area, we were told, had also increased somewhat. The rodent-menace had been checked by re-sectioning and reducing the size of field bunds. The cost of the scheme is to be recovered from the farmers in ten equal instalments, with interest at 7 per cent, the recovery of the first instalment commencing two years after the completion of the work. Based on the experience of Siddamalli, the scheme has already been extended to an additional 2,430 hectares, and in the proposed modernisation of the Cauvery Delta System, provision has been made to extend it to a total of 0.12 million hectares.

9.68 We recommend that effective steps be taken to gradually replace field-to-field irrigation of rice, by the system of field channels. There should be separate drains serving individual fields, as in Siddamalli.

Improvement in intensity

9.69 In Chapter V, we have already dealt with the subject of irrigation intensities. Low intensities obtain on the Upper and Lower Ganga Canals, the Eastern and Western Yamuna Canals and the Sarda Canal, to quote only a few cases.

9.70 We recommend that steps should be taken to improve the intensities of the various systems in the Indo-Gangetic plain by the increased use of groundwater, by the construction of storage reservoirs and by supplementing supplies by transferring water from an adjacent basin.

9.71 In the delta irrigation systems of south, both the designed and actual irrigation intensities are somewhat different from those in the north. In the Godavari System, for example, kharif rice is grown from June to December over practically the entire culturable commanded area. A second rice crop is grown over a portion of the commanded area from about the middle of January of April/May. Thus, actual intensities of just above 140 per cent have been achieved. Intensities higher than this could not be achieved because the area under the second crop has to be restricted to match the dwindling river flows in the latter part of the season. As more storage dams are constructed, higher intensities would, of course, be possible.

9.72 Even with the present water supply, it has been possible to extend the area under the second crop of rice by 20,000 to 40,000 hectares, by controlling pests and diseases, which enables the raising of paddy nurseries from the middle of December. The transplanting is done by the middle of January and the second crop is harvested by the end of March or, at the latest, in the first week of April, instead of April/May as now. Light irrigated crops such as cotton, ground-nut and hybrid jowar, require only one-third of the quantity of water consumed by rice and are very suitable for the second crop season.

9.73 In the Cauvery Delta which gets the benefit of both the south-west and the north-east monsoons, the intensity of irrigation at present is 133 per cent. Two-thirds of the area is put under a long-term crop of rice which is sown in the month of July and harvested in January. The remaining one-third grows two crops—the first from the middle of June to Sepember and the second from October to January/February.

9.74 In the northern portion of the Cauvery Delta, groundwater is fairly abundant, and farmers have installed filter-points to help in raising seedlings earlier in the season, and to some extent, in transplanting seedlings before the canal system opens. The use of groundwater and of high-yielding and short-duration varieties of rice has enabled some farmers to raise two crops over the entire area of their holdings. It should be possible to raise a third crop of ground-nut or cotton with the assistance of filter-points.

We have cited these examples to prove that intensities can be substantially increased in the rice zone.

9.75 We recommend, therefore, that efforts should be made to advance the second crop season in areas like the Godavari Delta, and to utilise groundwater as has been done in the Cauvery Delta, and to

promote the cultivation of light irrigated crops like ground-nut and cotton in the non-monsoon season.

9.76 The fact that intensities of 200 per cent are possible, has been proved by the experience in the Tambraparni System. The Tambraparni river rises in the Western Ghats and flows into the Bay of Bengal. Its total length is 137 km. and it commands an area of 33,600 hectares. Irrigation is done through diversion by a number of anicuts (weirs) most of which were built in pre-British days. The first short-duration crop of rice is raised between June and September and the second between October and March. With the completion in 1952 of a hydro-electric reservoir at Papanasam, crop failures due to poor monsoons are a thing of the past. Conditions were further improved by the construction of the Manimathar reservoir across a tributary of the Tambraparni. Apart from utilising river supplies, the system takes advantage of water impounded within the ayacut by 192 tanks of various sizes. These tanks store the surplus flows, the run-off of rainfall and the drainage of the foreshore irrigated areas, and contribute substantially to the high intensities obtained. An interesting feature of the system is the chain of tanks which are fed by channels taking off from the tail-end anicut. These tanks enable most of the flood-waters in the lower reaches of the river to be stored instead of flowing into the sea.

9.77 Although the total rainfall is by no means heavy, the area benefits from both monsoons. The average rainfall in the Tirunelveli district in which the command of the project lies is 300 mm. in the south-west monsoon and 450 mm. in the north-east monsoon. Through efficient water management, combined with the judicious use of storages in the upper reaches and in the ayacuts, which we have described, farmers in the command area of the Tambraparni can raise two crops in a year.

9.78 Short-duration, high-yielding varieties of rice as well as improved varieties of cotton, ground-nut, jowar and bajra have been evolved at agricultural research stations. It is also possible, now, to grow new high-yielding varieties of wheat in areas as far south as the Tungabhadra Project. All these crops can be successfully raised by a judicious use of water.

9.79 We recommend that existing systems should be examined on the lines which we have discussed and that new cropping patterns should be evolved to achieve increased intensities and to maximise production.

CHAPTER X

A PERSPECTIVE OF IRRIGATION DEVELOPMENT

We have been commissioned to indicate a broad perspective of development for irrigation of all types to achieve self-sufficiency in cereals and to maximise the production of other crops. A projection of this nature involves an assessment of the future food and fibre requirements of the country on the one hand and of the total useable water resources on the other.

10.2 Recent advances in agricultural research have opened up new possibilities for increased production, particularly with the use of water, high-yielding seeds, fertilizers, pesticides, etc. But this increase is feasible only in areas with assured sources of irrigation.

Some of the old canal systems, especially diversion works, are inadequate to meet the water requirements of high-yielding varieties of crops and in Chapter IX we have suggested measures for their improvement.

Of the net irrigated area of 27.5 million hectares in 1967–68, 10.3 million hectares were commanded by Government canals and 2.1 million hectares by tubewells. The rest relied on privately owned canals, tanks, wells and other sources. Irrigation by Government canals and tubewells is more reliable than that from other sources. It can, therefore, be said that not more than half of our irrigated area gets assured supplies and that not all irrigated areas can be relied upon to grow high-yielding varieties involving high investments on the part of farmers. Any reasonable plan for the development of irrigation must, therefore, aim first at firming-up supplies in areas already under irrigation. After this has been achieved every effort should be made to extend the acreage under irrigation from assured sources.

10.3 An important matter calling for attention is the disparity between dry and irrigated areas. A third of the country is prone to drought, which makes for low yields. Improved dry farming practices can no doubt improve yields, but the results achieved can at best be a fraction of those possible in irrigated areas. The growing disparity between the

two can be reduced only if steps are taken to improve irrigation facilities in the dry zones. The Commission has, therefore, made an assessment of the future possibilities of irrigation in the country. This perspective of development is thus not confined to the limited aim of increasing agricultural production, but has been extended to include the broader objectives of removing social and regional disparities.

Population

10.4 The population of India on the eve of Independence was 330 millions. It rose to 361 millions in 1951 and to 439 millions in 1961. An Expert Committee on Population Projection, set up by the Planning Commission, under the Chairmanship of the Registrar-General of India, submitted a report in 1968, giving projections of population on various assumptions up to the year 1986. The projected population, as worked out by this Committee, is indicated in the table below :

Table 10.1
Population Projections

(*Millions*)

Assumption	1971	1976	1981	1986
1	2	3	4	5
I	564	644	725	791
II	560	630	695	747
III	555	616	667	707
IV	560	625	680	723

The fourth assumption implied that the various family planning programmes recently taken up will take some time to show results and family planning would gain momentum in the latter half of the period.

10.5 The Committee also indicated certain projections of birth, death and growth rates. These are indicated in the Table 10.2

10.6 The provisional totals of the 1971 census reveal that the total population of India, as on 1st April, 1971 was 547 millions. The growth rate of 24.66 for 1960–70 closely tallies with the projected growth rate of 24.6 for 1966–70.

10.7 The demographers have not provided any firm population projection for the year 2,000 A.D. However, in the absence of any authen-

Table 10.2
Growth rate of Population

Period	Birth rate	Death rate	Growth rate (per thousand per annum)
1	2	3	4
1966–70 (Projected)	38.6	14.0	24.6
1961–71 (Actuals)	—	—	24.66
1971–75	35.1	11.3	23.8
1976–80	28.7	9.2	19.5
1981–85	22.7	8.2	14.5

tic forecast, the Commission hopes that the expected growth rate of 14.5 per thousand per annum, during the quinquennium 1981–85, will be maintained during the subsequent 15 years. On this basis, the population of India in the year 2,000 A.D. would work out to 900 millions, i.e. an increase of 65 per cent over the population of 1971. The food and fibre needs will however increase by about 100 per cent because of the likely rise in the standard of living. The country must, at the very least, produce twice its present output of food and fibre. Such an increase in production is possible if more and more areas are brought under irrigation which is a basic input for agricultural production. Irrigation should therefore receive prime attention.

Yield from Irrigated Areas

10.8 So far, no authentic data has been published about the yield from irrigated areas. The National Sample Survey (NSS) has carried out some crop-cutting experiments in the irrigated areas, but the results published are of limited scope. On our request, the Director, NSS, has furnished figures of yields for some irrigated areas and non-irrigated areas. However, this data is scanty and we have been advised not to draw any conclusions from it. The average yield under irrigated and unirrigated conditions in 1967–68 of some of the principal crops, according to the data sent to us, are as given on the next page.

Irrigated crops of paddy and wheat are estimated to yield 50 to 60 per cent more than unirrigated crops, but irrigated maize only about 30 per cent more. Cotton showed the maximum increase in yield under irrigated conditions, viz. about 150 per cent.

The average increase in irrigated paddy was reported to be about

Table 10.3

Average yield under irrigated and un-irrigated conditions in 1967–68

(Yield in kg. per hectare)

Crop	Irrigated	Unirrigated	Percentage increase in yield of irrigated over unirrigated crop
1	2	3	4
Paddy	1,299	857	52
Wheat	1,444	886	63
Maize	1,627	1,275	28
Cotton	281	111	153

440 kg. per hectare. It varied from State to State, and within the same State, depending upon a number of factors including rainfall and production techiques. It was also observed that the difference in yields between irrigated and unirrigated crops was larger and more significant in the low rainfall tracts of Andhra Pradesh, Mysore, Gujarat and Jammu and Kashmir.

10.9 Some information about yield from irrigated areas is available from the districts under the Intensive Agricultural Development Programme (IADP). This data covers not only the average yields of crops under irrigated and unirrigated conditions but includes the response of crops to irrigation, fertilizers, and manures. The following table presents the available information in the form of relative indices of average yield. They are only indicative of the combined contribution of irrigation and other inputs like fertilizers and manures.

Table 10.4

Indices of yields obtained in I.A.D.P. districts under different manurial practices

Crop	Dry farming		Irrigated farming		
	With no manures & fertilizers	With fertizers & manures	No fertilizers or manures	With fertilizers	With fertilizers & manures
1	2	3	4	5	6
Rice	100	152	144	177	177
Wheat	100	125	147	172	197
Maize	100	131	121	160	173

10.10 Rice, wheat and millets are the principal cereal crops. Next in importance are pulses, the important ones being gram and arhar. Pulses are particularly important, as the availability of animal protein in the country is low and they meet the protein requirements of the bulk of our population. Oilseeds are important as a cooking medium and provide fat in the diet. They are also the raw material for many industrial products. In analysing the future requirements of irrigation for our country, we have examined the present production, the areas irrigated and the future needs of irrigation for rice, wheat, pulses and oilseeds to achieve the desired level of production. We have also examined the position with regard to cotton, which is needed for meeting the cloth requirements of the population.

Rice

10.11 The table below indicates the area, production and yield per hectare and also the percentage of irrigated rice to the total area under rice in different States of India.

Table 10.5

Area. Production & Yield per hectare of rice. 1970–71*

Area : 000 *hectares*
Production : 000 *tonnes*
Yield : *Kg/hectare*

State	Area	Production	Yield	Percentage area irrigated (1967–68)
1	2	3	4	5
Andhra Pradesh	3,395.7	4,650.1	1,369	92.8
Assam (including Meghalaya)	2,099.9	2,130.3	1,014	33.6
Bihar	5,232.2	4,539.0	868	33.6
Gujarat	488.6	597.5	1,223	27.2
Kerala	874.8	1,271.1	1,453	56.9
Madhya Pradesh	4,333.7	3,646.8	841	13.3
Maharashtra	1,355.8	1,662.9	1,227	22.4
Mysore	1,159.8	1,952.9	1,684	62.0
Orissa	4,566.0	4,383.0	960	20.8
Tamil Nadu	2,686.2	5,303,4	1,974	92.9
Uttar Pradesh	4,553.0	3,729.3	819	15.0
West Bengal	4,949.1	6,104.7	1,233	28.2
All India	37,432.0	42,448.2	1,134	38.5

*Final estimates subject to revision.

Source: Indian Agriculture in Brief—Eleventh Edition.

10.12 Bihar leads in terms of area with 5.2 million hectares under rice, followed by West Bengal, Uttar Pradesh, Orissa and Madhya Pradesh with more than four million hectares each. However, the yields per hectare in Bihar, Madhya Pradesh, Orissa and Uttar Pradesh are low. These four States together account for more than 50 per cent of the area under rice, but produce only 40 per cent of the country's output. On the other hand, Andhra Pradesh, Mysore, Tamil Nadu and Kerala together account for 22 per cent of the area under rice but produce more than 30 per cent of the total output. This is explained by the fact that the rice area under irrigation is 92.8 per cent in Andhra Pradesh, 92.9 per cent in Tamil Nadu, 62.0 per cent in Mysore and 56.9 per cent in Kerala. Although the percentages in Mysore and Kerala are lower than those in Andhra Pradesh and Tamil Nadu, the west coast area in these two States gets very heavy rainfall during the kharif season, which accounts for their good yields. The yield per hectare is low in Madhya Pradesh, Bihar, Orissa and Uttar Pradesh, because the irrigated area under the rice crop is barely 13.3 per cent in Madhya Pradesh, 15 per cent in Uttar Pradesh, 20.8 per cent in Orissa and 33.6 per cent in Bihar. Rainfall in eastern Uttar Pradesh and Bihar is good but even here the crop suffers whenever the October (Hathia) rains fail. In fact, there is substantial variation in yield between western and eastern Uttar Pradesh. The yield in West Bengal is slightly better than in Bihar and Uttar Pradesh on account of the fairly good rainfall in most parts.

10.13 If the production of rice has to be improved and the growing demand for this important cereal is to be met, the obvious course would be to increase the irrigated area under rice in States like Bihar, Uttar Pradesh, Madhya Pradesh and Orissa. As discussed in subsequent paragraphs of this Chapter, there are considerable sources of surface and groundwater in these States which could be exploited to increase irrigation facilities.

10.14 The yield per hectare of paddy in other countries is given in Table 10.6.

10.15 The yields in India, even in the best irrigated tracts of Andhra Pradesh and Tamil Nadu, are much lower than those in Japan, U.A.R. and U.S.A. We should, therefore, aim not only at providing increased irrigation facilities in Uttar Pradesh, Madhya Pradesh, Bihar, Orissa and West Bengal, but also strive to increase yields per hectare in all irrigated areas by adopting high-yielding varieties and other inputs.

Table 10.6

Area, Production and average yield of paddy (unhusked rice) in selected countries of the World, 1969

Area : 000 *hectares*
Production : 000 *tonnes*
Yield : *Kg. per hectare*

Country	Area	Production	Yield
1	2	3	4
U.S.A.	861	4,120	4,790
Burma	4,678	7,785	1,710
India	37,680	60,645	1,610
Indonesia	8,209	16,197	1,970
Japan	3,274*	18,186	5,550
Pakistan	11,883*	21,584	1,820
Thailand	7,300[F]	13,410	1,840[F]
U.A.R.	500*	2,557	5,110

*Figure relate to area sown
F.=FAO estimates.
Source: FAO Production Year Book, 1970.

Wheat

10.16 The Table 10.7 indicates the area, production and yield per hectare and also the percentages of wheat under irrigation to the total area under this crop.

10.17 Punjab and Haryana which account for only 18 per cent of the area under wheat in the country produce more than 30 per cent of the gross output. Uttar Pradesh, Madhya Pradesh, Rajasthan and Bihar account for 65 per cent of the area under wheat but produce only 60 per cent of the gross output. The reason is obvious. The yield in Madhya Pradesh is low because only 10.6 per cent of the area under wheat is irrigated. The yield in Uttar Pradesh is also not as high as in Punjab and Haryana because the canals there provide only one or two waterings for the wheat crop, as against three or four provided by canals in Punjab and Haryana. The Punjab and Haryana irrigation systems derive their supplies from the Bhakra storage and are, therefore, more reliable. The practice of irrigation is also different in these two States. In Uttar Pradesh, the yield in the west is higher than in the east, because of the soils, climate and the nature of irrigation provided. Rajasthan, with a fairly high percentages of irrigation, records low yields because the soils are not as fertile as in Punjab and Haryana. The yield in Bihar is low

Table 10.7

Area, Production and Yield per hectare of wheat, 1970–71*

Area : 000 *hectares*
Production : 000 *tonnes*
Yield : *Kg. per hectare*

State	Area	Production	Yield	Percentage area irrigated (1967–68)
1	2	3	4	5
Bihar	1,230.0	1,192.1	969	38.4
Gujarat	577.2	939.4	1,628	63.7
Haryana	1,118.0	2,340.0	2,093	60.9
Madhya Pradesh	3,327.8	2,528.4	760	10.6
Maharashtra	882.0	451.1	511	26.7
Mysore	304.9	94.6	310	4.5
Punjab	2,200.0	4,873.0	2,215	70.5
Rajasthan	1,471.0	1,945.3	1,322	59.9
Uttar Pradesh	5,863.4	7,540.7	1,286	50.9
All-India	17,892.4	23,247.3	1,299	43.5

*Final estimates subject to revision.
Source: Indian Agriculture in Brief—Eleventh Edition.

on account of the low percentage of irrigation and also because the farmers have not yet adopted high-yielding varieties on any appreciable scale.

10.18 There could be a substantial increase in the production of wheat if large areas of Uttar Pradesh, Madhya Pradesh and Rajasthan are provided with assured irrigation. The yield in Bihar could also be increased if the cultivators are given assured irrigation and are encouraged to adopt new varieties.

10.19 The Table 10.8 indicates the area, production and yield per hectare in some selected countries of the world. The yield per hectare in India is below the world average.

Pulses

10.20 Pulses, particularly gram and arhar, constitute an important part of the protein diet of our population. The Table 10.9 indicates the area, production and yield of pulses in different States of India.

Table 10.8

Area. Production and average yield of wheat in selected countries of the World. 1969

Area : 000 *hectares*
Production : 000 *tonnes*
Yield : *Kg. per hectare*

Country	Area	Production	Yield
1	2	3	4
France	4.034	14.459	3.580
Italy	4.218	9.585	2.270
U.S.S.R.	66.426*	79.917	1.200
Canada	10.104	18.623	1.840
U.S.A.	19.253	39.740	2.060
Pakistan	6.277*	6.711	1.070
India	15.952	18.652	1.170
Australia	9.470*	10.834	1.140
Argentina	5.191	7.020	1.350
Iraq	2.089	1.189	570

*Figures relate to area sown.
Source: F.A.O. Production Year Book. 1970.

10.21 The yield per hectare is very low in the three principal pulse producing States of Madhya Pradesh, Maharashtra and Rajasthan. These three States account for 44 per cent of the area under pulses but produce only 33 per cent of the total output. Together with Mysore and Andhra Pradesh, where the yield per hectare is also low, the five States account for 55 per cent of the area under pulses, but produce only 38 per cent of the gross output. The yield per hectare is high in Haryana, Punjab, Uttar Pradesh and Bihar. These four States account for 35 per cent of the area under pulses, but harvest nearly 53 per cent of the gross production. The reason is not far to seek. The area of pulses under irrigation is appreciable in these States varying from 35 per cent in Punjab to 23.3 per cent in Haryana and 22.2 per cent in Uttar Pradesh. The yield is low in Andhra Pradesh, Mysore and Madhya Pradesh on account of the poor irrigation facilities (0.4 per cent, 0.5 per cent and 2.2 per cent respectively).

Oilseeds

10.22 The Table 10.10 indicates, State-wise, the area, production and yield per hectare of the major oilseeds, namely ground-nut, castor, sesamum, rapeseed, mustard and linseed. Soyabean has been making some progress in recent years.

Table 10.9

Area, Production and Yield per hectare of pulses, 1970–71*

Area : 000 *hectares*
Production : 000 *tonnes*
Yield : *Kg. per hectare*

State	Area	Production	Yield	Percentage area irrigated (1967–68)
1	2	3	4	5
Andhra Pradesh	1,386.1	243.5	176	0.4
Bihar	1,664.0	926.0	556	2.6
Gujarat	423.2	165.2	390	1.1
Haryana	1,144.2	814.2	712	23.3
Madhya Pradesh	4,055.3	1,889.5	466	2.2
Maharashtra	2,490.7	775.9	312	2.2
Mysore	1,131.3	403.6	357	0.5
Orissa	900.2	469.5	522	4.8
Punjab	407.4	311.0	763	35.0
Rajasthan	3,579.1	1,749.1	489	7.3
Tamil Nadu	463.5	109.5	236	1.6
Uttar Pradesh	3,782.7	3,102.7	820	22.2
West Bengal	838.3	497.8	674	5.8
All-India	22,423.4	11,575.7	516	8.7

*Final estimates subject to revision.
Source : Indian Agriculture in Brief—Eleventh Edition.

10.23 The yield per hectare is very low in Uttar Pradesh, Madhya Pradesh and Rajasthan. These three States account for 42 per cent of the area under oilseeds, but produce only 30 per cent of the gross output. The yield per hectare is good in Gujarat, Tamil Nadu, Orissa and Punjab. These four States account for 25 per cent of the area but produce 35 per cent of the gross output. This is because the area of the crop under irrigation is 16.8 per cent in Tamil Nadu and 22.7 per cent in Punjab. It is low in Madhya Pradesh, Rajasthan and Uttar Pradesh where the percentage is only 0.3 per cent, 4.0 per cent and 5.1 per cent respectively.

10.24 Oilseeds have an important role in the agricultural economy of India as they account for nearly 10 per cent of the total cultivated area. For several years, India has been ranking as the first in the world in point of the area under oilseed crops, and the production of oilseeds. but a closer examination of the relevant figures would reveal that although first in production, India ranks almost the last in yields per unit

Table 10.10

Area. Production and Yield per hectare of oilseeds. 1970–71*

Area : 000 *hectares*
Production : 000 *tonnes*
Yield : *Kg. per hectare*

State	Area	Production	Yield	Percentage area irrigated (1967–68)
1	2	3	4	5
Andhra Pradesh	2,059.6	1,251.2	607	9.3
Assam	149.1	62.2	417	—
Bihar	181.4	107.8	594	4.2
Gujarat	1,695.9	1,943.1	988	2.4
Haryana	141.6	97.3	687	16.7
Madhya Pradesh	1,542.0	532.1	345	0.3
Maharashtra	1,320.0	693.1	525	1.3
Mysore	1,001.1	664.9	664	—
Orissa	307.4	191.5	623	—
Punjab	280.3	212.6	758	22.7
Rajasthan	1,040.3	531.2	511	4.0
Tamil Nadu	1,129.6	959.0	849	16.8
Uttar Pradesh	3,964.9	1,826.8	461	5.1
West Bengal	157.3	50.1	318	—
All-India	15,345.7	9,187.5	599	5.0

*Final estimates subject to revision.

Source : Indian Agriculture in Brief—Eleventh Edition.

of area. For instance, in ground-nut the yield of nuts in the shell per hectare has shown a decline from 976 kg. per hectare in 1936–37 to 772 kg. per hectare in 1967–68 and a similar decline is seen in the other major oilseeds. Apparently, increase in production of oilseeds has been achieved by extending their cultivation to marginal lands. In the new strategy for agriculture now being forged, it is imperative that increase in production should mainly accrue from increased yields per unit of area.

Cotton

10.25 India occupies the foremost position among the cotton-growing countries of the world, with an area of eight million hectares cultivated annually. However, its total production ranks only fourth, with about 5.5 million bales of lint (392 lb. or 177 kg. per bale) because of the low average yield of lint per hectare. The most important reason for the low average yield is that nearly 84 per cent of the crop is raised

under rain-fed conditions, without adequate use of inputs, like water, fertilizers, pesticides, etc. There is also an enormous variation in the intensity and distribution of rainfall in the wide-spread cotton-growing tracts, leading to low average yield. Another important reason for the low average yield is that nearly 67 per cent of the crop is under the species *Gossypium arboreaum* and *Gossypium herbaceum*, whose production potential is inherently lower than that of the new world species such as *Gossypium hirsutum* and *Gossypium barbadense*, predominant types grown in other leading cotton-growing countries, like the U.S.A., U.S.S.R., U.A.R., etc.

10.26 The production, consumption, import, export and carry-over stocks of cotton in India during the past few years are indicated in the table below :

Table 10.11
Trends in production and consumption of cotton

(Million bales of 180 kg. each)

Year (Sept. to Aug.)	1960–61	1965–66	1966–67	1967–68	1968–69
1	2	3	4	5	6
Opening stocks with mills only	1.36	1.80	1.65	1.39	1.58
Home production (Trade estimates)	5.63	5.61	5.31	6.34	6.02
Imports	1.10	0.53	0.78	0.83	0.55
Total :	8.00	7.94	7.74	8.76	8.15
Mill consumption	5.38	5.82	5.76	6.17	6.20
House-hold consumption	0.27	0.27	0.27	0.27	0.27
Exports	0.30	0.18	0.24	0.24	0.20
Carry-over stocks (estimated)	2.14	1.67	1.47	2.08	1.48

10.27 The consumption of cotton in 1968–69 was 6.5 million bales, of which indigenous production accounted for six million bales. At least 10.8 million bales will be required to meet the requirements of 900 million people in 2,000 A.D. at present levels of consumption. As standards of living rise, the level of consumption may go up by about 50 per cent and the total requirement would be of the order of 16.2 million bales. In order to achieve this level of production, an important role will have to be assigned to irrigation.

10.28 The Table 10.12 indicates the area, production and yield per hectare of cotton in different States of India in 1970–71 :

Table 10.12

Area, Production and Yield per hectare of cotton, 1970–71*

Area : 000 *hectares*
Production : 000 *bales of 180 kgs. each.*
Yield : *Kg. per hectare*

State	Area	Production	Yield	Percentage area irrigated (1967–68)
1	2	3	4	5
Andhra Pradesh	320.0	140.0	79	3.1
Gujarat	1,581.8	1,571.3	179	12.7
Haryana	194.0	350.0	325	96.7
Madhya Pradesh	692.0	214.2	56	0.7
Maharashtra	2,811.6	481.7	31	2.1
Mysore	995.3	343.3	62	4.5
Punjab	397.0	819.0	371	95.7
Rajasthan	224.5	229.1	184	72.3
Tamil Nadu	310.8	344.9	200	29.3
All-India	7,609.8	4,555.7	108	16.7

*Final Estimates subject to revision.
Source : Indian Agriculture in Brief—Eleventh Edition.

10.29 Maharashtra, Gujarat, Mysore and Madhya Pradesh are the principal cotton-growing States accounting for 80 per cent of the area under cotton in the country. The yield per hectare varies widely from State to State, from as low a figure as 62 kg. per hectare in Mysore, to 371 kg. per hectare in Punjab. The high yields per hectare in Punjab and Haryana are largely the result of irrigation (96.7 per cent). Yields in Mysore, Madhya Pradesh and Maharashtra are low, because of the low percentage of cotton under irrigation. The yield in Gujarat, though not comparable to Punjab and Haryana, is better than in Maharashtra, Madhya Pradesh and Mysore, because of the higher percentage of irrigated area under cotton.

10.30 Experience in Punjab and Haryana and in the rice fallows in coastal Andhra Pradesh has shown that yields can be stepped up by as much as 200 per cent by the use of suitable varieties and improved practices. Efforts are being made through the 'Intensive Cotton District Programme' in irrigated areas to step up cotton production. But since only 16.7 per cent of the cotton area in the country is at present irrigated,

the resulting additional output may not touch even the fringe of the problem. Efforts should certainly be made to improve yields in rain-fed areas, but in view of the inherent low output of the varieties grown in such areas, it would be unrealistic to expect dramatic results. The only answer, therefore, appears to be to extend the cultivation of cotton more and more in irrigated areas.

10.31 As already indicated in Chapter III, the scope for bringing new land under the plough is limited. In the circumstances, we can only increase production if as much as possible of the area under cotton is provided with irrigation to facilitate the cultivation of high-yielding varieties. This can be done by exploiting the irrigation potential of new projects, such as the Rajasthan Canal, Nagarjunasagar, Tungabhadra, Pochampad, Purna, etc., to augment the area under irrigated cotton.

10.32 Cultivation of irrigated cotton in rice fallows in Andhra Pradesh and Tamil Nadu has yielded very promising results. A large-scale switch-over from rice to cotton in such areas would not only result in more efficient use of irrigation water in the dry season, but would also substantially increase the production of cotton. The Commission, therefore, recommends the extension of cotton to new areas, like fallow lands after the rice harvest in the delta areas of Andhra Pradesh, Tamil Nadu, Orissa and West Bengal.

10.33 Yields per hectare of cotton in other countries are as follows :

Table 10.13

Area. Production and average yield of cotton (lint) in selected countries of the World. 1969

Area : 000 *hectares*
Production : 000 *tonnes*
Yield : *Kg. per hectare*

Country	Area	Production	Yield
1	2	3	4
U.S.S.R.	2,540	1,950	770
Mexico	750	514	690
U.S.A.	4,475	2,179	490
U.A.R.	681	541	790
Brazil	4,195	697	170
India	7,712	942	120
Pakistan	1,757	538	310
Turkey	639	400	630
Sudan	491	225	460

Source : FAO Production Year Book, 1970.

10.34 The yield per hectare in India is very low compared to U.S.S.R., Mexico, U.A.R., U.S.A., and Turkey. Of late, a number of improved varieties of cotton have been released. Of these, Hybrid-4 (Gujarat), Sujata and Mcu. 5 (Tamil Nadu) and Krishna (Andhra Pradesh) combine high yields with good quality. In addition, a number of varieties, such as A. 218 (Punjab) PS-9, PS-10 (Haryana) RS. 79 (Rajasthan) IAN-579 (188) and 3943 (Gujarat) and Suvin (Tamil Nadu) are in different stages of trial. The rapid extension of these varieties to suitable areas and the adoption of intensive cultivation practices should help to improve yields substantially. Even in rain-fed areas there is need for intensive cultivation with the existing improved varieties through the application of a basal dose of fertilizers, foliar application of urea, and the adoption of other dry farming techniques. More research is also necessary to produce new high-yielding and short-duration varieties, and to develop a suitable improved technology for the rain-fed areas.

Sugarcane

10.35 India produces over one-fifth of the world's sugarcane output. The crop accounts for only one to two per cent of the total sown area in the country but as the water requirements of this crop are very high, we have considered it worthwhile to indicate the area and production trends. Cane products like sugar and gur are important in the dietary of people as a source of energy.

The overall area under sugarcane was 2.7 million hectares in 1970–71 compared to 1.7 million hectares in 1950–51 i.e., an increase of about 56 per cent during a period of 20 years. Its production increased during this period from 57.1 million tonnes to 128.8 million tonnes that is by 126 per cent. The increase in production was partly due to expansion of area and partly due to increase in productivity.

The total production of sugar and gur during 1969–70 was 11.4 million tonnes. Sugar is a priority item in the family budget and the demand for it is bound to rise with increase in population and rise in the standards of living. The production of sugarcane in the country has also to be doubled during the next 25–30 years in order to meet the increasing requirements of sugar and gur.

The Table 10.14 gives the area, production and yield of sugarcane in the important cane growing States of India in 1970–71. It also indicates the percentage area of the crop irrigated.

The yields are high in Maharashtra, Mysore, Andhra Pradesh and Tamil Nadu, where the crop is grown under assured irrigation and the climate is congenial for its growth all through the year. In States like Uttar Pradesh, Bihar, Punjab and Haryana yields are generally low.

Table 10.14
Area, Production and Yield of sugarcane, 1970–71

Area : 000 *hectares*
Production : 000 *tonnes*
Yield : *Quintals per hectare*

State	Area	Production	Yield	Area irrigated in 1967–68 (percentage)
1	2	3	4	5
Andhra Pradesh	135.4	10,508.3	776	97.6
Bihar	162.0	6,493.9	401	27.4
Haryana	155.0	6,980.0	450	84.3
Maharashtra	217.2	14,770.0	680	100.0
Mysore	96.7	8,482.8	877	100.0
Punjab	128.0	5,270.0	412	82.6
Tamil Nadu	135.0	10,443.4	774	100.0
Uttar Pradesh	1,368.6	55,663.8	407	67.5
All-India	2,657.0	128,769.4	485	73.9

This is mainly due to lack of adequate irrigation and drainage facilities. Further, irrigation from run-of-the-river systems obtaining in some of these States is not sufficient, particularly during the summer months.

The average yields obtaining in States like Maharashtra, Mysore, Andhra Pradesh and Tamil Nadu compare well with those in countries like United States and Australia. However, the national average of 485 quintals per hectare is low and there is considerable scope for raising production.

Sugarcane requires adequate rainfall and/or reliable irrigation facilities throughout the year. Doubling of production during the next 25–30 years will therefore involve mainly :

(a) firming up irrigation in areas where facilities are at present inadequate;
(b) providing irrigation to the unirrigated crop as in Bihar; and
(c) extending the area under the crop in regions where assured, perennial irrigation from storage systems is available.

In the new project areas, suitable blocks should be localised for sugarcane cultivation. If this is not possible, the crop should be limited to areas where irrigation needs during the hot weather season, that is January to May, can be met from ground water sources, or to areas where tail-race waters are available from hydro-electric projects.

The adoption of high-yielding varieties of cane, increased use of inputs like fertilizers and pesticides etc. will help to raise the production further.

10.36 The preceding reviews indicate that significant results can be achieved in increasing yields of principal crops if proper attention is given to irrigation particularly in the States mentioned below:

Rice	Bihar	West Bengal	Uttar Pradesh	Orissa
Wheat	Uttar Pradesh	Madhya Pradesh	Rajasthan	Bihar
Pulses	Madhya Pradesh	Rajasthan	Maharashtra	Bihar
Oilseeds	Uttar Pradesh	Gujarat	Andhra Pradesh	Madhya Pradesh
Cotton	Maha-rashtra	Gujarat	Mysore	Madhya Pradesh

Irrigation Potential

10.37 No systematic study of the irrigation potential of the country has so far been made. The few estimates that have been prepared suffer from all the limitations imposed by the lack of full information. We provide below an outline of the efforts so far made.

10.38 In the 'fifties', the Central Water & Power Commission (CW&PC) made an attempt to assess the irrigation potential of different river basins on the basis of information furnished by the States, and their own examination of topo-sheets. Detailed surveys of large parts of the country were, however, missing and the study was limited and incomplete in scope.

10.39 Since then some States have made attempts to estimate their irrigation potential. Others have had techno-economic surveys made by the National Council of Applied Economic Research. The Council's estimate of the irrigation potentials of various States was based on available material and discussions with State officers. The Planning Commission, as part of its data collection activities, also attempted to work out the irrigation potential of the country. Taking into account the various figures and estimates available, the Planning Commission assessed in 1963, that the ultimate irrigation potential of India from major and medium irrigation works was of the order of 45 million hectares.

10.40 About the same time, the Ministry of Food and Agriculture (Department of Agriculture) also made an assessment of the minor irrigation potential of the country both from surface and groundwater resources. Its studies indicated that an area of 30 million hectares could be irrigated with minor irrigation schemes. But subsequently, when the Fourth Five Year Plan was formulated, the Working Group on Minor Irrigation and Rural Electrification revised this figure to 36 million hectares, comprising 14 million hectares from surface water resources and 22 million hectares from groundwater.

10.41 In our Questionnaire, we had inquired from the States whether they had prepared any Master Plans for the exploitation of surface and groundwater resources and requested them to give us all the available information regarding all irrigation works (surface and groundwater) investigated so far. Most of the States have not been able to furnish a reasonably accurate assessment of future possibilities and even where some figures have been indicated, it appears that they are based on rough assessments. The figures given by the States are indicated in column 6 of the table below :

Table 10.15
Ultimate Irrigation Potential - State-wise

(Million hectares)

State	Ultimate Potential					Area irrigated (1966–67)
	Major* and Medium Projects	Minor Projects**		Total	As per State Replies	
		Surface Water	Ground Water			
1	2	3	4	5	6	7
Andhra Pradesh	6.5	2.0	1.8	10.3	8.7	3.9
Assam	1.0	1.0	0.2	2.2	1.3	0.6
Bihar	4.4	1.8	1.8	8.0	5.8	2.0
Gujarat	2.1	0.5	1.2	3.8	2.6	1.1
Haryana	@	0.05	0.8	0.85	2.4	1.8
Jammu & Kashmir	0.1	0.4	0.1	0.6	0.4	0.3
Kerala	0.6	0.8	0.1	1.5	—	0.5
Madhya Pradesh	5.6	0.8	1.6	8.0	—	1.1
Maharashtra	2.3	0.8	1.4	4.5	6.2	1.4
Mysore	1.8	0.8	0.8	3.4	5.5	1.2
Nagaland	n.a.	0.05	—	0.05	n.a.	0.02
Orissa	2.4	1.2	0.4	4.0	—	1.1
Punjab	4.1	0.1	1.9	6.1	—	3.4

Table 10.15—Contd.
Ultimate Irrigation Potential—State-wise

(Million hectares)

State	Ultimate Potential					Area irrigated (1966–67)
	Major* and Medium Projects	Minor Projects**		Total	As per State Replies	
		Surface Water	Ground Water			
1	2	3	4	5	6	7
Rajasthan	3.2	0.4	1.4	5.0	3.2	2.1
Tamil Nadu	1.5	0.8	1.3	3.6	3.4	3.4
Uttar Pradesh	7.6	1.0	6.5	15.1	25.5	7.2
West Bengal	2.3	1.2	0.8	4.3	—	1.5
Union Territories	n.a.	0.3	0.1	0.4	—	0.1
Total :	45.5	14.0	22.2	81.7	—	32.8

*Fourth Five Year Plan (1969–74)—Planning Commission.
**Working Group Report for formulation of Fourth Plan Proposals on Minor Irrigation & Rural Electrification.
@ Included in Punjab.
n.a.—not available.

10.42 We set down hereafter the figures of total irrigation potential which the States have intimated, the more important of the projects and also our own appraisal of the future irrigation possibilities.

10.43 *Irrigation Potential as assessed by States*

Andhra Pradesh

The total irrigation potential of the State had been estimated in 1963 at 10.3 million hectares of which 6.5 million hectares are accounted for by major and medium schemes. In its Preliminary Memorandum to us, the State Government indicated that the ultimate irrigation potential would be 8.7 million hectares. The area irrigated at present is four million hectares. The important projects in operation, under construction and proposed to be taken up in the future, according to the data furnished by the State Government, are :

Projects in operation	*Area irrigated* (hectares)
Krishna delta canal system	494,000
Godavari delta canal system	508,000
K.C. Canal	
Tungabhadra low level canal	60,000
Nizamsagar	76,000

Projects under construction	*Area under irrigation*	*Area to be irrigated on full development*
	(hectares)	
Nagarjunasagar	380,000	830,000
Pochampad		230,000
Tungabhadra high level canal	32,000	90,000

Projects contemplated	*Area proposed to be irrigated* (hectares)
Vamsadhara	60,000
Inchampalli	182,000
Pranhita	101,000
Ippur reservoir and Polavaram barrage	678,000
Sangameshwaram Stages I & II	437,000
Bhima	162,000
Upper Krishna	73,000
Peddavagu	13,000
Penganga	12,000

Assam

The irrigation potential of Assam had been estimated in 1965 at 2.2 million hectares. The State Government, in its replies to our Questionnaire, indicated the ultimate irrigation potential as 1.3 million hectares. The area for which irrigation is available is 0.6 million hectares. Development in the future will consist largely of lift irrigation schemes from the Brahmaputra and its tributaries and the construction of tubewells in the Brahmaputra valley.

Bihar

During the Third Five Year Plan period, Bihar's irrigation potential had been estimated at 8.0 million hectares. The State had set up an Irrigation Commission in 1967 and this Commission has assessed the irrigation potential of Bihar at 5.8 million hectares. The present development, taking into account the area irrigated by the Kosi and Gandak, is 2 million hectares. The principal projects in operation, under construction and those contemplated in the future are :

Projects in operation	*Area irrigated* (hectares)
Son canal system	275,000
Triveni canal system	48,000

Projects under construction	*Area under irrigation*	*Area to be irrigated on full development*
	(hectares)	
Kosi eastern canal	255,000	570,000
Gandak	118,000	1,141,000
Son high level canal		121,000

Projects contemplated	*Area proposed to be irrigated* (hectares)
Western Kosi Canal	325,000
North Koel	178,000

Gujarat

During the Third Plan period, Gujarat's irrigation potential had been estimated at 3.8 million hectares. In reply to our Questionnaire, the State Government has estimated total irrigation potential at 2.6 million hectares. The present development is of the order of 1.1 million hectares. The irrigation potential from the Narmada project has not been indicated as the matter is subject to adjudication of a Tribunal. The principal projects in operation, under construction and contemplated are indicated below :

Projects in operation	*Area irrigated* (hectares)
Mahi canal system	186,000
Kakrapar canals	228,000

Projects under construction	*Area under irrigation*	*Area to be irrigated on full development*
	(hectares)	
Ukai		160,000
Mahi Stage II		90,000

Projects contemplated	*Area proposed to be irrigated* (hectares)
Narmada	

Haryana

In its replies to our Questionnaire, the State Government indicated Haryana's ultimate irrigation potential as 2.4 million hectares. The present irrigation is of the order of 1.8 million hectares. The important schemes in Haryana are :

Projects in operation	*Area irrigated* (hectares)
Bhakra canal system	680,000
Western Yamuna Canal	547,000
Gurgaon canal	102,000

Projects under construction	*Area under irrigation*	*Area to be irrigated on full development*
	(hectares)	
Improvement of Western Yamuna Canal	174,000	248,000
Lift irrigation schemes		
Tubewells (under construction)		

Projects contemplated	*Area proposed to be irrigated* (hectares)
Other lift irrigation schemes	
Tubewells (New)	
Improvement of intensity in Western Yamuna Canal and other areas from storages on the Yamuna	

Jammu & Kashmir

The State Government indicated the total irrigation potential as 0.4 million hectares. Present irrigation is 0.30 million hectares. The important irrigation works are :

Projects in operation	*Area irrigated* (hectares)
Ranbir canal	48,000
Pratap canal	6,000

Projects under construction	*Area under irrigation*	*Area to be irrigated on full development*
	(hectares)	
Tawi lift irrigation		14,000

Projects contemplated	*Area proposed to be irrigated* (hectares)
Lift irrigation scheme	

Kerala

According to the studies carried out by the Planning Commission in 1965, the ultimate irrigation potential of Kerala was estimated at 1.56 million hectares. In its replies to our Questionnaire, the State Government has not indicated any specific figure although a number of new projects have been mentioned as being feasible. The important ones are :

Projects in operation	*Area irrigated* (hectares)
Malampuzha	39,000

Projects under construction	*Area under irrigation*	*Area to be irrigated on full development*
	(hectares)	
Periyar valley irrigation scheme	22,000	57,000
Kuttiadi		31,000
Pamba		34,000
Kallada		110,000

Projects contemplated	*Area proposed to be irrigated* (hectares)
Vamanapuram	10,000
Iddiki Tailrace	
Kuriarkutty	9,000
Kakkadavu	
Chinmoey-Mupply	8,000
Karappara	
Edmalayar	

Madhya Pradesh

Madhya Pradesh has not furnished any estimate of its total irrigation potential, presumably because the allocation of waters of the Narmada and the Godavari are subject to adjudication by Tribunals. According to an estimate prepared by the Planning Commission in 1965, the total irrigation potential of Madhya Pradesh was 8.0 million hectares. The important projects in operation, under construction and contemplated are :

Projects in operation	*Area irrigated* (hectares)
Mahanadi canal system	88,000
Tandula canal system	65,000

Projects under construction	*Area under irrigation*	*Area to be irrigated on full development*
	(hectares)	
Chambal canal	105,000	283,000
Tawa		332,000
Barna		63,000

Projects contemplated	*Area proposed to be irrigated* (hectares)
Bargi	215,000
Narmadasagar (Punasa)	243,000
Bansagar	249,000
Hasdeo (Bango dam)	239,000
Omkareshwar	139,000
Ken	121,500
Sabari (Konta)	429,000

Maharashtra

In its replies to our Questionnaire, the State Government indicated the total irrigation potential in Maharashtra as 6.2 million hectares. This is based on the finding of the Maharashtra Irrigation Commission which submitted its report in 1962. The entire irrigation potential of the State had been examined by that Commission in a systematic manner. The important projects in operation, under construction and contemplated are :

Projects in operation	*Area irrigated* (hectares)
Godavari canals	24,000
Pravara canals	30,000
Nira canal system	72,000
Ghod	25,000

Projects under construction	*Area under irrigation* (hectares)	*Area to be irrigated on full development* (hectares)
Mula		60,000
Bagh	2,000	25,000
Jayakwadi Stage I		160,000
Bhima		170,000
Krishna		110,000
Kukdi		59,000

Projects contemplated	*Area proposed to be irrigated* (hectares)
Dudhganga	77,000
Koyna irrigation	59,000
Upper Godavari	90,000
Jayakwadi Stage II	251,000
Penganga	152,000
Lower Wainganga	97,000
Pench	94,000
Kanhar	134,000

Mysore

In its Preliminary Memorandum to the Irrigation Commission, the State Government has indicated its total irrigation potential at 5.5 million hectares. According to the study carried out by the Planning Commission in 1965, the total irrigation potential was 3.4 million hectares. The Krishna and the Cauvery basins constitute 78 per cent of the total area of the State. The Krishna dispute is already before a Tribunal. The important projects in operation and under construction are :

Projects in operation	*Area irrigated* (hectares)
Tungabhadra low level canal	360,000
Ghataprabha Stage I	70,000
Bhadra	100,000
Krishnarajasagar	40,000

Projects under construction	*Area under irrigation* (hectares)	*Area to be irrigated on full development* (hectares)
Ghataprabha Stage II	13,000	50,000
Malaprabha		220,000
Upper Krishna Stage I		270,000
Kabini		51,000
Hemavathi		40,000

Nagaland

There are no major and medium irrigation schemes in Nagaland. Only a few lift irrigation schemes are feasible and the area to be benefited is only 20,000 hectares.

Orissa

In its replies to the Questionnaire, the State Government has not indicated any figure for the ultimate irrigation potential in Orissa. The Planning Commission had estimated the total irrigation potential at four million hectares in 1965. Dr. A.N. Khosla, while he was Governor of the State, had published a brochure entitled 'Orissa's Decade of

Destiny'. This publication refers to a number of new schemes. The important projects in operation, under construction and contemplated are :

Projects in operation	*Area irrigated* (hectares)
Mahanadi Delta system	100,000
Hirakud canal system	280,000
Rushikulya system	3,000
Orissa coast canals	111,000

Projects under construction	*Area under irrigation*	*Area to be irrigated on full development*
	(hectares)	
Mahanadi delta project	333,000	690,000
Salandi	37,000	62,000

Projects contemplated	*Area proposed to be irrigated* (hectares)
Anandpur Barrage	159,000
Bhimkund	25,000
Upper Indravati	76,000
Burabalong-Subarnarekha	364,000
Balimela Irrigation	155,000
Upper Kolab	129,000
Manibhadra Barrage	

Punjab

The State Government has not indicated its total irrigation potential. Here again the uncertainty connected with the final allocation of the waters of the Ravi, Beas, Sutlej seems to have been the barrier. The present development of irrigation is 3.4 million hectares. The important schemes in operation, under construction and contemplated are :

Projects in operation	*Area irrigated* (hectares)
Bhakra canal system	1,230,000
Sirhind Feeder	
Upper Bari Doab Canal	368,000
Sirhind Canal	600,000
Eastern Canal	141,000

Projects under construction	*Area under irrigation*	*Area to be irrigated on full development*
	(hectares)	
Beas Project Units I & II		420,000

Projects contemplated	*Area proposed to be irrigated* (hectares)
Thein Dam	

Rajasthan

According to the assessment made in 1965 by the Planning Commission, the ultimate irrigation potential of Rajasthan is 5.0 million hectares. The State Government has, however, indicated in the preliminary document sent to us that the total irrigation potential is 3.2 million hectares. The present development of irrigation is 2.1 million hectares. The important schemes in operation, under construction and contemplated are :

Projects in operation	*Area irrigated* (hectares)
Gang Canal	294,000
Chambal canals	280,000
Bhakra canals	230,000

Projects under construction	*Area under irrigation*	*Area to be irrigated on full development*
	(hectares)	
Rajasthan Canal	202,000	1,270,000

Projects contemplated	*Area proposed to be irrigated* (hectares)
Yamuna storage and lift scheme	

Tamil Nadu

According to the estimates prepared by the Planning Commission in 1965, the total irrigation potential of Tamil Nadu was placed at 3.70 million hectares. In its replies to the Questionnaire, the State Government has indicated the total irrigation potential as 3.4 million hectares, which is the same as the present development of irrigation. The important projects in operation, under construction and contemplated are :

Projects in operation	*Area irrigated* (hectares)
Cauvery delta system	425,000
Periyar irrigation scheme	59,000
Lower Coleroon anicut system	54,000
Lower Bhavani Project	79,000
Cauvery Mettur	104,000

Projects under construction	*Area under irrigation*	*Area to be irrigated on full development*
	(hectares)	
Parambikulam Aliyar Project	57,000	100,000

Projects contemplated	*Area proposed to be irrigated* (hectares)
Modernising Tanjavur channels	58,000

Uttar Pradesh

The State Government has indicated that the total irrigation potential is 25.5 million hectares. This estimate is based on the assumption that 25 per cent of the culturable area in hill districts, 50 per cent in Bundelkhand and the eastern districts of Varanasi and Mirzapur and 80 per cent in the rest of the State would be provided with irrigation facilities and that there would be 200 per cent intensity over the irrigated area in the

Gangetic plains. The important projects in operation, under construction and contemplated are :

Projects in operation	*Area irrigated* (hectares)
Upper Ganga Canal	695,000
Lower Ganga Canal	592,000
Agra Canal	159,000
Eastern Yamuna Canal	191,000
Betwa Canal System	120,000
Ken Canal	96,000
Sarda Canal	593,000

Projects under construction	*Area under irrigation*	*Area to be irrigated on full development*
	(hectares)	
Ramganga	89,000	660,000
Project Assist		620,000

Projects contemplated	*Area proposed to be irrigated* (hectares)
Greater Gangau	
Tehri, Kotli-Bhel	1,200,000
Kishau	
Pancheswar	809,000
Rajghat	524,000
Karnali	809,000
Pumped canals	
Tubewells	

West Bengal

According to the studies carried out by the Planning Commission in 1965, the total irrigation potential of West Bengal was 5.1 million hectares. The present development of irrigation is of the order of 1.5 million hectares. The important projects in operation, under construction and contemplated are :

Projects in operation	*Area irrigated* (hectares)
Damodar canal system	90,000
Midnapore Canal	40,000
Mayurakshi	250,000

Projects under construction	*Area under irrigation*	*Area to be irrigated on full development*
	(hectares)	
Damodar Valley Corporation		360,000
Kangsabati Project	119,000	380,000

Projects contemplated	*Area proposed to be irrigated* (hectares)
Upper Kangsabati	60,000
Teesta	546,000
Lift irrigation schemes	
Tubewells	

10.44 Tribunals have been constituted under the Inter-State Water Disputes Act to adjudicate disputes over the waters of the Krishna, the Godavari and the Narmada. The total irrigation potential of Andhra Pradesh, Mysore, Maharashtra, Madhya Pradesh, Orissa and Gujarat cannot, therefore, be worked out until these Tribunals announce their decisions. In reply to our Questionnaire Gujarat indicated that its total irrigation potential will be 2.6 million hectares plus whatever could be achieved with its share of the Narmada waters. This appears to be a reasonable approach and in making our estimates we propose to adopt it in respect of Andhra Pradesh, Mysore, Maharashtra, Madhya Pradesh and Orissa who are all parties before the Tribunals.

10.45 The Commission has also come across cases where the projects proposed by two or more States in the same river valley are mutually exclusive. Obviously some of these competitive projects will have to be modified or dropped. Which of these projects would ultimately be sanctioned and in what form, can be determined only after the completion of river basin plans and agreement amongst the States concerned. Therefore the total irrigation potential suggested by the States is liable to be reduced on this account.

10.46 Some States have furnished the names of projects and the areas likely to be irrigated by them but the figures of irrigated areas are not based on investigations. In most cases these figures are based on preliminary Topo-sheet studies. In the absence of technical feasibility studies or detailed investigations the Commission cannot accept all the figures communicated by the States. The Commission would however like to emphasise that investigations of all projects should be carried out expeditiously and project reports prepared. This would facilitate the preparation of basin plans and the projects can be taken up for execution without delay at the appropriate time.

10.47 There is another factor about which full and correct information is not at present available, i.e. the ground water potential of each State. No doubt a great deal of work has been done in the past few years to assess the ground water resources but a complete assessment for the whole country has not so far been carried out. At best, the estimates of ground water potential are based on certain assumptions and guesses which may not turn out to be correct.

Subject to these limitations, the Commission has assessed the future potential as below :

10.48 *Irrigation Potential as assessed by the Commission*

Andhra Pradesh : State's estimate—8.7 million hectares.

The Krishna and the Godavari basins cover 54 per cent of the State's area. Since the question of the allocation of waters in both these river basins is before the Krishna and the Godavari Tribunals, it is not possible to indicate the total irrigation potential of Andhra Pradesh.

The State Government has recently constituted a Ground Water Cell. We suggest that detailed investigations for assessing the ground water potential be completed expeditiously.

Assam : State's estimate—1.3 million hectares.

Keeping in view the recent developments in lift and tubewell irrigation we accept this figure. Detailed investigations should be carried out to finalise the location of various lift irrigation schemes, the size, number and spacing of tubewells etc.

Bihar : Bihar Irrigation Commission Report—5.8 million hectares.

This includes 1.06 million hectares from the Kosi. During our discussions at Patna with the Chief Administrator, River Valley Projects Department, and other officials of the Kosi project, doubts were expressed whether the Eastern Kosi Canal could actually irrigate all the area as

originally envisaged. The matter calls for a thorough technical examination, as the Kosi carries a very heavy silt charge and practical difficulties exist in keeping the canal open to carry the full discharge. Therefore, it is likely that the potential initially envisaged may not be realised and alternative sources such as ground water may have to be exploited on a larger scale.

As a result of the experience gained in operating the Eastern Kosi Canal, there is great need for caution in designing, constructing and operating the Western Kosi Canal. The extent to which the ground water potential can be exploited to meet the irrigation requirements of the areas proposed to be served by the Western Kosi Canal must be investigated.

As regards the Eastern Kosi Canal, its operation would need careful consideration. It would appear desirable to limit its running in kharif to the minimum when the river water is heavily charged with silt. In addition, the arrangements for silt exclusion and silt ejection should be further improved.

Considering the limitations of the Kosi and other schemes contemplated for north Bihar, the Commission is inclined to estimate the total irrigation potential of the State at about 4.9 million hectares. This figure may be raised if future investigations reveal that ground water exploitation on a bigger scale is possible.

Gujarat : State's estimate—2.6 million hectares plus irrigation from the Narmada.

We agree with the State's estimate and Gujarat's potential may be placed at 2.6 million hectares plus the areas to be irrigated from the Narmada.

*Haryana**

Haryana's share of the Ravi, Beas and Sutlej waters has not yet been finally determined. Its share in the proposed Yamuna storage project (Kishau or any other site nearby) has also yet to be defined. The State has a programme to develop a number of lift irrigation schemes and also to expand its tubewell programme. The present irrigated area of the State is 1.8 million hectares. The proposed lift irrigation schemes and tubewells should add another 0.4 million hectares. Haryana's total irrigation potential would thus be 2.2 million hectares, plus such additional areas as can be irrigated by its share of the Ravi, Beas, Sutlej and Yamuna

*State's estimate not communicated.

waters. We have indicated elsewhere that it should be possible to lift surplus Yamuna waters during the monsoon season to irrigate dry areas in Haryana.

Jammu & Kashmir : State's estimate—0.4 million hectares.

We accept this figure.

*Kerala**

The State Government has not furnished any figures of its total irrigation potential, but considering the enormous water potential of Kerala, we would put it at 1.6 million hectares.

Madhya Pradesh : State's estimate—6.5 million hectares.

The State is a party to disputes pending before the Narmada and the Godavari Tribunals. The two river basins cover 34 per cent of the total area of the State. The Commission has, therefore, not been able to arrive at any firm figure for the irrigation potential of Madhya Pradesh. However, considering the enormous water resources of the rivers flowing through it and the possibilities of ground water exploitation, it may not be incorrect to presume that the irrigation potential of Madhya Pradesh would be roughly of the order of 6.1 million hectares plus such areas as can be irrigated with water allocated to it from the Narmada and the Godavari.

Maharashtra : State's estimate—6.1 million hectares.**

Maharashtra is a party to the dispute before the Krishna and the Godavari Tribunals. We are, therefore, unable to project any firm figure of its total irrigation potential.

*Mysore**

Mysore is a party to the dispute before the Krishna and the Godavari Tribunals and therefore it is not possible for us to project the total irrigation potential of the State. The potential of other river basins such as the Cauvery, the Palar and west-flowing rivers have been estimated by the State Government. The new projects in the Cauvery basin are

*State's estimate not communicated.

**Maharashtra Irrigation Commission Report of 1962.

disputed by Tamil Nadu. In view of the uncertainties due to disputes before the Tribunals and the dispute with Tamil Nadu regarding the Cauvery, the Commission is unable to express any opinion about the final irrigation potential of the State.

Nagaland

In view of the lack of water resources and of culturable land, a few lift irrigation schemes may be found to be feasible, but the limited areas benefited from them may be of the order of 20,000 hectares.

*Orissa**

Of the projects contemplated, Upper Indravati, Upper Kolab and Balimela Irrigation are in the Godavari basin which is under dispute before a tribunal. Other projects in the Baitarni, the Subarnarekha and the Mahanadi basins present no difficulty and can be considered on the merits as soon as investigations are completed. Taking into account, schemes already completed, under construction and now contemplated, the total irrigation potential of Orissa may be put at 4 million hectares, plus the potential in the Godavari basin.

*Punjab**

The final allocation of the Ravi, Beas and Sutlej waters between Punjab and other States has not yet been determined. It is, therefore, not possible at this stage to project the final total irrigation potential of Punjab. The State Government has set up a Tubewell Corporation to exploit ground water resources. It may, therefore, be presumed that the total potential of Punjab including the present irrigated area of 3.4 million hectares may be of the order of 4 million hectares, plus or minus, depending upon the final allocation of Ravi, Beas and Sutlej waters.

Rajasthan : State's estimate—3.2 million hectares.

We have referred to the possibility of exploiting the surplus monsoon flows of the Yamuna through lift irrigation schemes. Taking into account these possibilities and schemes envisaged by the State Government, as also the ground water recently located at a number of places, the total irrigation potential of 3.2 million hectares appears reasonable.

*State's assessment not indicated.

*Tamil Nadu**

The State has almost exhausted its water potential. It should however be possible to improve and modernise the existing canal systems and thereby expand irrigation. The possibility of exploiting ground water is being investigated under a United Nations Development Programme in the Cauvery delta and near Madras city. Taking into account the likely effect of improvements to the existing canal systems and of ground water exploitation, the total irrigation potential of the State may be placed at 3.6 million hectares.

In both Kerala and Tamil Nadu we consulted State Government officers whether it would be possible to divert more west-flowing rivers to the east for irrigation. We were given to understand that there are a few proposals under consideration. It would be worthwhile to examine some lift-cum-storage-cum-diversion schemes to utilise the surplus monsoon flows of the Kerala rivers. We are unable at the moment to estimate with any accuracy the likely effect of these schemes, but would suggest that the States of Kerala and Tamil Nadu should explore these possibilities.

Uttar Pradesh : State's estimate—22.5 million hectares.

In reply to our Questionnaire, the State Government has stated that its aim is to achieve an intensity of 200 per cent on all irrigated land. We discussed this question with the Chief Minister, the Irrigation Minister and officials of the State Government and enquired how an intensity of 200 per cent was possible. We were told that there were new methods for increasing the water potential, such as re-charging ground water aquifers by employing a technique suggested by Dr. Rama of the Tata Institute of Fundamental Research. This technique has not been tried anywhere and we find it difficult to include any increase in potential because of this method in our estimates. However, if at any time, the State can achieve an intensity higher than what we estimate, it would be welcome.

Assessment of irrigation potential on the basis of assumed intensities is not a satisfactory method. However, in the absence of any systematic determination of surface and ground water resources or of project reports, we accept, for a broad assessment, an intensity of 150 per cent for the Gangetic Plains and 100 per cent for the hill districts and Bundelkhand areas. We have worked out the future irrigation potential of Uttar Pradesh on the basis of the data furnished by the State Government, referred to in paragraph 10.43 and our conclusions are as follows :

*Actual irrigation—3.4 million hectares.

Table 10.16
Irrigation Potential of Uttar Pradesh

(Million hectares)

Region	Net cultivated area	Percentage irrigated	Net area to be irrigated	Intensity	Gross area to be irrigated
1	2	3	4	5	6
Hill districts	0.65	25	0.16	100%	0.16
Bundelkhand & Eastern districts of Varanasi and Mirzapur	2.43	50	1.21	100%	1.21
Rest of the State	14.18	80	11.34	150%	17.01
Total :	17.26				18.38
				Say :	18.00

We would adopt the figure of 18 million hectares as total irrigation potential of Uttar Pradesh.

*West Bengal**

The State Government has indicated only Upper Kangsabati and the Teesta barrage for new construction. The possibility of constructing tubewells and lift irrigation schemes has also been mentioned. Taking these into account, the irrigation potential of the State may be placed at 3.2 million hectares.

Priorities for Future Development

10.49 The development of future irrigation may be broadly classified into five groups :

(1) Completion of schemes already in hand;
(2) Exploitation of minor irrigation potential of the country during the next 10 years;
(3) Improvement of existing irrigation works;
(4) Investigation, sanction and execution of all medium schemes in different parts of the country during the next 15 years; and
(5) Investigation, design and construction of major and multipurpose river valley projects in a phased manner during the next 25–30 years.

*State's estimate not furnished.

10.50 Out of the utilisable 203,500 m. cu. m. of ground water 111,000 m. cu. m. have been exploited already, leaving a balance of 92,500 m. cu. m. The Fourth Plan envisages the development of 7.9 million hectares under minor irrigation, utilising both surface and ground waters. Assuming that this tempo will be accelerated in subsequent Plans, it should be possible to exploit the remaining potential during the next ten years.

10.51 In the last 20 years, more than 500 medium irrigation schemes have been taken up, and more than three-fifths of them have already been completed. Most of the States now have Investigation Circles or Divisions engaged in carrying out detailed investigations and preparing medium schemes. It should be possible, with better planning and coordination, to carry out investigations for all the remaining medium irrigation schemes in the next 5–7 years. With suitable phasing of works and allocation of funds, it should not be difficult for the States to start working on these schemes during the next 10–12 years and to complete them in about 15 years. Hence, we recommend that minor works should be completed in a period of 10 years and medium works in the course of the next 15 years.

Conservation of water resources

10.52 In 1947, the total storage of all irrigation works in India was of the order of 12,300 m. cu. m. (10 MAF). In 1970–71 it has risen to 123,300 m. cu. m. (100 MAF). The addition, no doubt, is appreciable, but considering that the average annual utilisable flow of our river systems is 1,672,600 m. cu. m. (1,356 MAF) the utilisation is still highly inadequate.

10.53 Out of the storage of the 123,300 m. cu. m., 77,700 m. cu. m. are accounted for by 14 storage works (listed below) each with a capacity of 2,500 m. cu. m. (Two MAF) or more. 13 other works contribute a storage of 22,200 m. cu. m. each with a capacity of 1,250 m. cu. m. (One MAF). Thus 27 works account for 99,900 m. cu. m. out of the 123,300 m. cu. m. of total storage in India.

10.54 More than 90 per cent of the flow in our river systems occurs in the monsoon months of June to September. It is obvious that unless storages are built to hold back the monsoon flows we will not be able to utilise those waters for irrigation in the following winter and summer seasons.

Table 10.17
Large storages—existing and under construction

River System/Storage site	Live storage	
	m. cu. m.	M.A.F.
Storages of more than 2500 *m. cu. m.*		
1. Bhakra	7,450	6.04
2. Pong	6,970	5.65
3. Rihand	8,980	7.28
4. Gandhisagar	6,900	5.60
5. Hirakud	5,830	4.73
6. Nagarjunasagar	7,730	6.27
7. Pochampad	3,170	2.57
8. Ukai	7,100	5.76
9. Srisailam	5,090	4.13
10. Sharavathi	6,540	5.30
11. Koyna	2,690	2.18
12. Tungabhadra	3,710	3.01
13. Mettur	2,660	2.16
14. Balimela	2,840	2.30
Storages of more than 1250 *m. cu. m. but less than* 2500 *m. cu. m.*		
1. Bhadra	1,790	1.45
2. Kadana	1,220	0.99
3. Rana Pratapsagar	1,590	1.29
4. Mahi Bajajsagar	2,010	1.63
5. Hidkal (Ghataprabha)	1,420	1.15
6. Krishnarajasagar	1,250	1.01
7. Jayakwadi	2,070	1.68
8. Bhima	1,700	1.38
9. Tawa	2,100	1.70
10. Iddiki	1,470	1.19
11. Maithon	1,360	1.10
12. Panchet	1,330	1.08
13. Ramganga	2,210	1.79

10.55 Out of our 40.5 million irrigated hectares, the perennial flows of the Himalayas account for about four million hectares only. Tubewells account for another 2.4 million hectares. The rest of the area depends for its water supply on storages and river diversion schemes, and shallow aquifers.

10.56 The surest way of providing assured irrigation in a big way is to harness the flow of rivers with big storages. They have large catch-

ments and any variation in rainfall or seasonal fluctuations in downpour would not affect these reservoirs to the same extent as it does small tanks. During the droughts in 1965 and 1966, the failure of tanks was widespread.

10.57 On the basis of the information furnished by the State Governments and other available data, 25 sites listed in the table below have been identified, each capable of providing a storage of more than 1,250 m. cu. m. This list is not exhaustive.

Table 10.18
Large storages of the future

River System/Storage site	River	Live Storage m. cu. m.
Indus		
1. Thein	Ravi	
Ganga		
2. Tehri	Bhagirathi	3,340 (Gross)
3. Kotli Bhel	Ganga	
4. Kishau	Tons—Yamuna	
5. Pancheswar	Sarda	
6. Karnali	Ghaghra	
7. Bansagar	Son	
8. Rajghat	Betwa	2,380
9. Ken (Greater Gangau)	Ken	
Narmada		
10. Bargi	Narmada	3,470
11. Punasa	Narmada	10,360
12. Hiranphal/Navgam	Narmada	
Godavari		
13. Pranhita I		3,120
14. Pranhita II		
15. Pench		1,090
16. Indravati		11,640
17. Sabari		2,830
18. Inchamapalli		11,040
Krishna		
19. Dudhganga		590
20. Kasari		1,230
21.		

Table 10.18—Contd.

River System/Storage site	River	Liver Storage m. cu. m.
Kerala		
22. Edmalayar		
Gujarat		
23. Dharoi	Sabarmati	780
Baitarni		
24. Bhimkund		3,700
Mahanadi		
25. Tikkerpara		48,870

Note :— Some of the projects mentioned above have been investigated. But a few are yet to be investigated and their technical feasibility determined. The names and live capacities indicated in the table are therefore only indicative of the future possibilities and are not to be considered as final or of bearing the Commission's acceptance.

Water Resources, Food & Fibre Needs and Irrigation Potential

10.58 The perspective development outlined above takes into account the various improvements to existing works suggested by us in Chapter IX. These improvements, by and large, would provide assured, timely and adequate supplies to existing irrigated areas. In some cases, like the Pancheswar Project, irrigation may be extended to new areas. In a few others like the 'Modernisation of Cauvery Delta' the area under second crop may be raised. All this additional irrigation has been taken into account in the total potential assessed by us.

10.59 The big irrigation projects generally take 8–10 years for construction and not less than another 6–7 years for full development of irrigation potential. In Chapter VII we have outlined the steps to be taken for the speedy development of the ayacuts. However considering the financial outlays involved and the magnitude of the task it would not be incorrect to presume that the benefits from some of the big irrigation projects taken up for construction, say 20 years hence, would spill over beyond the year 2000 A.D.

10.60 There is also one other aspect of irrigation works to be kept

in view. Some of the reservoirs already built have shown signs of silting up and reduction in capacity. We have indicated in Chapter XIV that soil conservation in river valley projects should be taken up on a high priority. This would mitigate much of the damage that is occurring or is likely to occur in the future. Nevertheless, the potential is likely to be affected by silting of reservoirs, though in a limited measure.

10.61 Although we are unable, at present, to indicate any State-wise break-up of the irrigation potential in the Godavari, the Krishna and the Narmada basins, we are of the view that these basins, on the basis of the data now available, hold promise of developing not less than 20 million hectares of irrigation.

10.62 Taking into account the perspective of irrigation development assessed in the preceding sections and also the possibilities of irrigation development in the Godavari, the Krishna and the Narmada basins, the total irrigation potential of the country, both from surface and ground water resources, will be of the order of 81 million hectares. This would mean that about 50 per cent of our total area under crops can be provided with irrigation facilities.

10.63 Rice and wheat constitute the principal irrigated crops today and they will continue to be so in future when all the irrigation potential is exploited. These two crops together account for 60 per cent of our gross irrigated area. Assuming that the proportion of crops under irrigation would, more or less, remain as they are, with some marginal changes, the overall water requirement per crop hectare irrigated will be of the order of 0.76 m. This would mean that for irrigating 81 million hectares there would be a need of 616,000 m. cu. m. In Chapter III, we have indicated that the total utilisable surface water resources are of the order of 666,000 m. cu. m. and the ground water resources are of the order of 204,000 m. cu. m., i.e., a total of 870,000 m. cu. m. The domestic and industrial water needs, according to present estimates, work out to 150,000 m. cu. m. by 2000 A.D. This would leave about 720,000 m. cu. m. for consumptive use in irrigation works. The water resources needed for irrigating 81 million hectares would thus be available from the estimated surface and ground water resources.

10.64 Our present irrigation is 36.4 million hectares. If the total potential of 81 million hectares is developed by the turn of the century it would enable us to double the production of food and fibre, particularly keeping in view the increase in production due to improved varieties of seeds, fertilizers, pesticides, etc. in areas with assured irrigation.

Such a development would not only ensure self-sufficiency in 2000 A.D. but also lay a sound basis for increased production in subsequent years.

Outlay on Development

10.65 The cost per hectare of most of the major and medium irrigation projects sanctioned during the last few years varies from Rs. 1,500 to Rs. 3,500 and averages around Rs. 2,000. Projects undertaken in the future will be more expensive than those already built or now under way, because of their difficult location and technical complexity. Some of them would also involve lifting of water which is more expensive. It may, therefore, be reasonable to assume that the future schemes, on an average, will cost at least Rs. 3,000 per hectare at current prices, as against Rs. 2,000 per hectare in the past. On this rough basis, the cost of future development may work out to about Rs. 100,000 million.

10.66 The Fourth Plan envisages an investment of Rs. 15,000 million on major, medium and minor irrigation schemes. Assuming that in each succeeding Plan, the investment would be 1.5 times that of the previous Plan, an investment of Rs. 100,000 million would require four Plan periods. Allowing for the inevitable delays in investigation, project formulation, sanction and execution, it would be reasonable to expect that the development of the irrigation potential envisaged in this Chapter would take about 25–30 years from now. In other words, it should be possible to develop the total irrigation potential, as envisaged at present, by the turn of the century.

10.67 The perspective of irrigation development may, therefore, be summed up as follows :

(1) Scope for expanding the area under cultivation is limited. The additional requirement of food and fibre has, therefore, to come mostly by increased yields on existing cultivated land;
(2) The ultimate irrigation potential from major, medium and minor works, as known now, is of the order of 81 million hectares;
(3) Development to date is 36.4 million hectares;
(4) Development of minor irrigation has, in recent years, gained great momentum and if this tempo is kept up, the balance potential of minor irrigation can be developed during the next 10–12 years. The medium irrigation schemes should be executed during the next fifteen years;
(5) To meet the vagaries of the monsoon, and in order to place Indian agriculture on a stable footing, it is necessary to provide

good storage backing to irrigation systems. The present storage is inadequate. Steps should, therefore, be taken, during the course of the next 15–20 years, to take up 25–30 projects which would provide adequate storage.

The projects should be so phased for investigation, planning and construction that optimum use is made of the country's resources in men, machinery and finance;

(6) The cost of developing the balance potential, according to present indications is Rs. 100,000 million;

(7) Judging from past performance and the present rate of progress, it is within the competence of the Union and State Governments to develop the balance potential during the next 30 years.

Application of new concepts in Irrigation Development

10.68 In America and the USSR, Governments are now considering large scale transportation of water from one region to another involving huge lifts and cross country diversions. There are proposals to transfer water from Alaska to California and Mexico traversing the Canadian West, the Rocky Mountains and numerous great rivers and mountain ranges. It is also proposed to transport the waters of the Mississippi river to Texas involving lifts of 610 to 914 metres. The USSR is contemplating diverting some of the Siberian rivers into the Aral Sea.

10.69 The possibility of linking the Ganga and the Cauvery with canals has been the subject of thought and discussion for a long time in this country. Towards the middle of the last century, Sir Arthur Cotton had talked of such a link and early in this century, it had been visualised as a possibility by Shri C.P. Ramaswamy Iyer. The proposal has again been reviewed recently by the Ministry of Irrigation and Power. A UNDP Team has been invited to examine its technical feasibility and socio-economic impact. Although the project has not yet been investigated sufficiently to enable the precise details of the link to be described, according to preliminary thinking, some 1,130 cumecs of water will be pumped during the monsoon whenever the flow from the Ganga below Patna exceeds 2,830 cumecs. The pumping will be carried out in stages. The Son-Narmada ridge will be crossed through a tunnel and the water will be let into the Bargi reservoir on the Narmada. It will then flow down to Pochampad on the Godavari and from there to the Cauvery. The aggregate lift involved from the Ganga to the Cauvery will be 457 m. with 22.5 to 24 km. of tunnels. The power requirements for pumping would be six million kilowatts. The projects falls into three distinct sections—Ganga to Narmada, Narmada to Godavari and Godavari to

Cauvery—and can be taken up in stages. Electricity at a fairly low cost for pumping will be furnished by the use of secondary power from hydro-electric schemes like the Karnali and Bansagar. No State would be deprived of firm power through the diversion of electricity to the project.

10.70 Although for purposes of description, the project has been talked of as the Ganga-Cauvery link, it does not necessarily imply that it will be the water from the Ganga which will be taken to the Cauvery. Water from the Ganga would be pumped into other systems making it possible for water from these systems to be used lower down. The link would, therefore, take the shape of a grid and the transfer of Ganga water would enable the grid to operate in such a manner as to make up periodical shortages in the Son, Narmada, Godavari, Krishna and Cauvery systems. We support the proposal for the investigation of this gigantic project.

10.71 Similarly, the monsoon flows in the Yamuna can be lifted and taken to the dry districts of Hissar and Mohindergarh in Haryana and Jhunjhunu in Rajasthan. The lift involved would not exceed 152 m. and the water could be pumped for about a hundred days during the monsoon. Natural depressions such as the Kantli river near Nim-ka-Thana offer possibilities of storing this water which can then be used for kharif or rabi crops to augment supplies of ground water. It could also be used for reducing salinity in an estimated 0.4 million hectares of saline-affected land.

There are also possibilities of pumping water from the Ganga, the Ken and the Son rivers to store it in reservoirs in south Bihar and south-eastern Uttar Pradesh. Natural depressions such as the Phalgu river near Gaya could be used for storing this water in south Bihar. The water of the Son and Ganga can be pumped 152 to 305 m. for storing in reservoirs in the drought affected districts of Varanasi, Mirzapur and Banda. It is expected that nearly 0.4 million hectares could be brought under irrigation in this manner.

10.72 Another possible method of utilising the surplus surface monsoon flows is by diverting them to recharge ground water aquifers so that the water can be withdrawn for rabi cultivation. Lands which are left fallow in the kharif season in parts of the Ganga plains could be profitably utilised in the recharging of ground water aquifers.

10.73 The possibility of using the recharging device should also be considered for desert areas in Rajasthan, drought affected areas in north

Gujarat and parts of Madhya Pradesh, Maharashtra, Mysore and Andhra Pradesh, particularly the Bijapur and Dharwar districts of Mysore and the Rayalaseema area in Andhra Pradesh. Although, the process is difficult and expensive, it could be an effective method of bringing relief to these areas. We recommend that a detailed investigation into all such possibilities should be made.

Domestic and Industrial Water Requirements

10.74 We had asked the State Governments to provide us with some idea of the amount of water required for domestic and industrial purposes now and in the future. Some of the States have sent replies while others have not. We envisage that it is probable that by the turn of this century almost all the cities and towns in India will be provided with healthy drinking water facilities and possibly more than 50 per cent of the rural areas would be provided with protected drinking water. The estimates of the likely industrial water requirements of India have been the subject of studies carried out by the Planning Commission and other institutions. These studies indicate that the future requirements are likely to be of the order of 30,000 m. cu. m. for domestic use and 50,000 m. cu. m. for industrial purposes. Although no precise estimates of State demands for cooling thermal and nuclear power stations can be made at this stage, it would be prudent to allow, say 50,000 m. cu. m. for this purpose by the turn of the century.

Thus a total of 130,000 to 150,000 m. cu. m. of water should be set apart for uses other than irrigation.

The Ecological Balance

10.75 Ecology or the science of environment has attracted great attention in recent years. Man is shaped to a great extent by his surroundings. His physical nature, his mental health, his culture and institutions, his opportunities for challenge and fulfilment and his very survival are all related to, and affected by, the environment in which he lives. The construction of huge reservoirs and new canal systems in areas hitherto barren, affects the environment. Some of the effects are beneficial and others are not. The introduction of canal systems may change the ground water balance, making available drinking water for human beings and cattle, it may change the flora and the fauna of the area and thus affect the environment of a particular zone. The construction of a dam and the creation of huge reservoirs affects the river system lower down, as has happened in a number of cases. The diminishing flows of the river system below a dam can increase the pollution hazard lower down; it can also

affect the availability of drinking water and lead to the silting up of river beds and consequential-heavy damage during times of floods and rains. The creation of reservoirs has also been known to affect the hinterland of the dam. Sometimes there have been tremors and earthquakes, introduction of new plants in the water-spread of the lake etc.

10.76 A recent example of the ill-effects of the construction of a dam is the high Aswan dam in Egypt. When an international team of ecologists studied the effects of the dam they were shocked. For one thing, waterweeds are clogging the shoreline of Lake Nasser behind the dam. The weeds may well speed evaporation through transpiration to the point where the lake may not have enough water to move the gigantic turbines.

10.77 The dam has also stopped the flow of silt down the Nile, which in the past used to offset the natural erosion of the land in the delta. As a result, downstream erosion may wash away as much productive farm land as is opened up by the new irrigation systems of Lake Nasser. As the nutrient-rich silt does not reach the Mediterranean, the Egyptian sardine catch has declined from 18,000 tonnes in 1965 to 500 tonnes in 1968. Irrigation projects on the delta plain have also allowed a moisture-loving snail to thrive. This creature carries 'schistosomiasis', which is a human health hazard, manifesting itself in the form of an agonizing liver and intestinal disease.

10.78 In India, the recent earthquake in the Koyna area has been attributed by some scientists to the creation of the Koyna lake. The proposal for the construction of the Tikkerpara dam on the Mahanadi was seriously opposed, as it was feared that salt water may intrude into the Mahanadi delta. Deprived of the fertile silt of the Mahanadi which would be trapped in the Tikkerpara lake, the delta lands would be impoverished. The construction of the Damodar reservoirs has affected the regime of the river lower down. The damage caused by the flood in the Damodar now, is more severe than what it was a few years ago.

10.79 The Rajasthan Canal will flow through barren desert on the north-western frontiers of the country and will change the entire ecological balance in that region. Water will flow for the first time in these arid areas, bringing fresh opportunities for cultivation. The flora and fauna of this region will change, as has already happened in the Ganganagar district.

10.80 In the perspective of irrigation development, care has, therefore,

to be taken while planning big reservoirs and huge canal systems, not to disturb the ecological balance adversely. There may be occasions when certain levels of flow have to be maintained in the river systems, even at the cost of irrigation, so that the ecological balance lower down below the dam is not unduly disturbed. There may be occasions when the lake levels may have to be fluctuated by releases to prevent undesirable growths in the lake or as an anti-malaria measure. Occasionally the canal systems may have to be lined to prevent waterlogging and salinity. These precautions are necessary to maintain the ecological balance.

CHAPTER XI

ECONOMICS AND FINANCING OF IRRIGATION WORKS

Criteria for sanctioning Irrigation Projects

There has to be a norm or criterion for judging the utility of an irrigation project before it is sanctioned. Various criteria have been adopted in the past. In recent years there was a complete switch-over from the criterion of financial productivity to that of economic benefit as represented by the benefit-cost ratio. While examining the merits of this change, it would be of interest to recall the events which led to it.

11.2 In its publication entitled 'Criteria for Fixation of Water Rates and Selection of Irrigation Projects', the National Council of Applied Economic Research has made a study of the history of investment criteria. According to the study—

> "PRIOR to 1854, in India there was no separate account for the revenue and expenditure of the irrigation works. The irrigation charges were included in the revenue account. It was only after 1853, when a separate account was instituted for various irrigation works, did it become necessary to evolve the criteria for investment in irrigation. After much thought and discussion, the question was settled by the Select Committee of the House of Commons in 1879 which stated that the financial results of works of irrigation are, in the opinion of the Committee, the best test of their utility".
>
> "The Committee also recommended that the financial results of an irrigation project in India should be tested as follows :
>
> (i) By considering the capital cost of any work as simply the sum actually spent on its construction.
>
> (ii) By debiting the revenue account yearly with—
>
> (a) the simple interest on the capital cost of the works at the commencement of the year; and

(b) the working expenses of the year.

(iii) By crediting the revenue account yearly with—

(a) direct receipts; and

(b) indirect receipts.

"The difference between (ii) and (iii) for one year would show the profit or loss for that year. Schemes were to be sanctioned only if they satisfied the test of financial productivity, arrived at in terms of rate of returns calculated as suggested in (i), (ii) and (iii) above; the test of financial prodictivity being that the project should be able to show a certain percentage return on the sum-at-charge in the tenth year after its opening, the sum-at-charge being the capital cost plus the arrears of interest up to that year. This principle was followed since then and the rate of return required before a project could be considered as financially productive was fixed variously from time to time. It was fixed at 4 per cent for works sanctioned before 1st April, 1919, 5 per cent for works sanctioned between 1st April, 1919, and 1st August, 1921; and 6 per cent for all works sanctioned after that date. From 1st April, 1949, it was fixed at 3.75 per cent, but from August, 1954, it has been fixed again at 4.5 per cent—a rate which continues to this day".*

"There was some dissatisfaction with this criteria at the end of the 19th century on the ground that the financial test was too rigorous and that there were many indirect benefits of irrigation to the country as well as to the Government, which were unaccounted for on the credit side. The Government, therefore, appointed a Royal Commission on Irrigation in 1901 which examined the question of indirect benefits. The Commission, after great deliberation, favoured the financial productivity test then being used. In a broad manner it conceded that many indirect benefits accrued to the community from irrigation facilities, but held that they were not substantial, and that if they were substantial at all, they were more or less in proportion to the direct benefits as measured in terms of direct financial receipts to the State. Therefore, they held that there was no need to change the existing financial productivity test in any way".

11.3 The financial productivity test continued to be rigidly applied

*The rate was increased to 5 per cent from 1-4-1960 and to $6\frac{1}{2}$ per cent for a period of three years from 1-4-1969, being 1 per cent above the present long-term rate of borrowing of the Union Government of $5\frac{1}{2}$ per cent.

to all irrigation projects even after 1920 when, as a result of the Montague-Chelmsford Reforms, irrigation was transferred from the Government of India to the Provincial Governments. Protective irrigation works which did not satisfy the financial criteria were taken up from time to time, but these were few and far between. At the time of Independence, irrigation works in the country, as a whole, yielded a net profit of 8 per cent, after meeting the cost of maintenance, and interest charges.

11.4 The earlier large irrigation schemes were mostly diversion works and were relatively inexpensive. But later on, when new schemes were taken up it was felt that the development of irrigation was being held up by the rigid application of the financial criterion—6 per cent between 1921 and 1949. It was argued that apart from direct irrigation revenues, other benefits accrued to the Government in the shape of increased revenue from excise duties, income-tax, sales-tax, transport, etc. As a result, the Central Board of Irrigation passed a resolution at its Seventh Annual Meeting in 1936 stating "that as the expansion of irrigation is seriously handicapped by the restricted view taken of the value of irrigation, an economic survey should be carried out with a view to estimating the direct and indirect financial benefits accruing to the Central and Local Governments from irrigation projects". But the financial criterion continued to be applied although studies showed that the indirect benefits from irrigation projects were substantial. However, it was conceded that if a project did not fulfil the financial criterion but was still considered necessary in the public interest, it could be sanctioned as a protective work.

Benefit-cost Ratio

11.5 With Independence, the development of irrigation was stepped up. The lowering of the rate of return in the productivity test in 1949, from 6 per cent to 3.75 per cent, enabled a larger number of projects to be accepted for construction. But, in spite of this, there were many who still felt that the indirect benefits of irrigation should also be taken into account. In 1958, the Planning Commission initiated studies of five major, well-established, irrigation projects, namely, the Sarda Canal, the Gang Canal, the Tribeni Canal, the Damodar Canal and the Cauvery-Mettur project. The aim was to assess the overall benefits and to find a better criterion for deciding whether various irrigation projects ought to be undertaken. These studies, guided by a Committee of Direction headed by Prof. D.R. Gadgil were completed in 1961 and showed that large benefits accrued from irrigation in terms of double cropping, diversification and better quality crops, higher yields, larger income and

greater employment opportunities for hired labour. Indirect benefits were the establishment of processing industries, the expansion of consumer industries, retail trade, and transport and communications. It became clear that the total benefits from irrigation were far larger than the direct financial returns accruing to Government from irrigation rates. The Committee, therefore, recommended that in future the benefit-cost ratio should be used for assessing the feasibility of new projects instead of the traditional criterion of the direct financial return to Government. For the sake of simplicity, it also proposed that the indirect or secondary benefits need not be taken into account. In working out the ratio, the benefit should be taken to comprise the difference in the value of total annual agricultural production less the cost of cultivation, before and after the introduction of irrigation. The cost should be taken to comprise the annual interest on capital, depreciation, and expenditure on maintenance and operation.

11.6 In 1964, the 'Committee to Suggest Ways and Means of Improving Financial Returns from Irrigation Projects' recommended that the economic benefit criterion should be adopted for sanctioning irrigation projects, instead of the financial criterion. The Government accepted this recommendation and the benefit-cost ratio criterion has since been in use. We agree that the latter, though not faultless, is more suitable than the financial return criterion. Financial return depends upon the charges levied for the water supplied and these charges can be altered at will and arbitrarily. But not so the components of the benefit-cost ratio, which denotes the economic worth of a project.

11.7 We would like to mention here the 'Rate of Return' criterion used by the World Bank in 1970, while sanctioning a loan for the Kadana Irrigation Scheme. In the benefit-cost ratio, the benefit represents the total gains accruing from a project, and the cost represents the expenditure involved in producing them, all in terms of current values. The rate of return deals with a different aspect, as it connotes a ratio between the current annual net benefits from a project and the capital investment on the project. The *inter-se* ranking of two projects can be different with these two criteria. The rate of return method, which is more complicated than the simplified benefit-cost ratio, is more suited as a basis for making a choice between two investments and where financial return is the dominant consideration and no constraints are imposed by national goals. Of these two criteria, we recommend the continued use of the benefit-cost ratio, for irrigation projects. It is not only simpler, but is also widely used in most countries, particularly in the ECAFE region.

11.8 The application of the benefit-cost ratio criterion in recent years has, however, had certain undesirable effects. It minimises the importance of securing an adequate return from investments on irrigation projects. We feel that this trend must be checked. We recommend, therefore, that at the time of considering a project for acceptance, the financial return of the project should also be carefully examined. If the return does not cover working expenses and interest charges on capital, the impact of the project on the irrigation revenues of the State should be examined to see if an upward revision of water rates in the State would be necessary. If an upward revision appears to be necessary, the State should be advised accordingly at the time of conveying approval of the project.

11.9 We notice that the present instructions are to adopt a rate of interest of 10 per cent per annum in calculating the benefit-cost ratio. This may appear to be unduly high, but we approve of it, because in underdeveloped countries there is a real scarcity of capital, and it is necessary to allow for a higher rate of interest for closer conformity with commercial values. The interest rate should reflect the prevailing demand for capital and on this consideration a 10 per cent rate of interest is not inappropriate. A higher rate of interest also covers some of the risks that arise on account of the uncertainty as to whether a project will be able to produce benefits right through its estimated working life.

11.10 We are informed that projects with a benefit-cost ratio of less than 1.5 are generally not considered for acceptance, although theoretically a ratio of unity should meet the criterion. We consider this to be a prudent precaution. We have come across several instances where project costs have increased twofold or even more while the rise in commodity prices has been much less. A lower benefit-cost ratio than 1.5 would, in these circumstances, lead to the acceptance of marginal projects which may later prove to be economically unsound. We would, however, recommend that this rule should not be rigidly applied in the case of irrigation projects in the drought affected areas. Apart from economic considerations, there are often pressing social and human reasons to justify expenditure on irrigation works in such areas. A lower limit of one for the benefit-cost ratio may be accepted for such projects even if they later prove to be somewhat uneconomical.

11.11 In the case of multipurpose projects, the benefit-cost ratio has to be worked out for the project as a whole to ascertain whether it is justified on economic grounds. The benefit-cost ratios also need to be worked out for each benefit on the basis of apportioned costs, in order

to see whether any particular aspect of the project is unjustified on economic grounds.

11.12 As a rough check on the feasibility of a project, the norm of the cost of irrigation per hectare or the cost of storage per million cubic metre is applied. While these norms are handy for a rough appraisal, they are no substitute for a thorough appraisal based on the benefit-cost ratio.

Consideration of Ayacut Development and Conservation of Catchment

11.13 The cost estimates of irrigation projects cover all works up to outlets and include the cost of constructing water courses, and in some States, even field channels. But they do not include the cost of ayacut development, for which separate estimates are prepared. At present, in working out the benefit-cost ratio the investment on ayacut development is not taken into account. This, in our view, gives a distorted picture of the economic viability of a project. It is obvious that the full benefits, for which credit is taken in the benefit-cost ratio, can accrue only after land has been shaped, and field channels and field drains have been constructed.

11.14 In the U.S.A., the Sub-Committee on Evaluation Standards stated in its report to the Inter-Agency Committee on Water Resources in 1958 that "all costs of development and improvement of agricultural land and all production costs must be considered in project evaluation". In 1964, the Gadgil* Committee in its report on 'Criteria for Appraising the Feasibility of Irrigation Projects', stated as under :

> "When irrigation newly comes to a region, the lands used till then for dry irrigation have to be adapted and prepared for irrigated agriculture. This involves a capital cost for the preparation of land to receive water. This is in the nature of a capital investment on the part of the farmer and is to be treated on the same lines as an annual charge in the form of depreciation. The problem then becomes as to what should be the period over which this capital charge should be retired. We suggest that it should be ten years. The capital costs on this account will have to be estimated by the Project authorities and these can be easily done. In fact, as in the U.S.A., conventions may be adopted by which these costs should be included in the project costs".

*Shri D.R. Gadgil was Director of the Gokhale Institute of Economics and Politics, Poona, and later Deputy Chairman of Planning Commission.

This particular recommendation of the Gadgil Committee seems to have been lost sight of, as subsequent instructions issued on the subject of benefit-cost ratio make no mention of it. We recommend, therefore, that in making an economic appraisal of an irrigation scheme, the project cost and the cost of land shaping and of constructing field channels and field drains should all be taken into consideration. We further recommend that instead of retiring the capital investment on land shaping, field channels and field drains in a period of ten years through depreciation, the investment should be treated as an outlay on which interest is paid annually.

11.15 During our discussions with the State Governments a fear was expressed by some that a joint appraisal of an irrigation project and its ayacut development, particularly the operations of land levelling and land shaping, would show the project to be less attractive, and for this reason there may be some difficulty in securing approval. We have examined this apprehension by studying a few cases for which data could be had. It is only in a portion of the ayacut that land levelling or land shaping is necessary in a project. The proportion requiring this treatment varies from project to project depending upon the nature of the terrain in the command area. Likewise, the cost per hectare of land levelling and land shaping varies from place to place. But the effect of including this cost in working out the benefit-cost ratio would be relatively small.

11.16 Soil conservation measures in the catchment area of a storage irrigation project have great significance for the life of the storage reservoir. These measures generally comprise bunding, terracing, afforestation and pasture development. A good watershed development plan will serve more than one purpose. It would lead to higher agricultural production in the catchment area through increased yields, improve forest and grasslands and, therefore, income from such land, exercise a moderating influence on medium and small floods, improve low flows in the streams, and reduce silt yield from the catchment. These benefits are difficult to quantify and evaluate with precision. Though it could be argued that a portion of the investment on soil conservation measures in the catchment should be taken into account in working out the benefit-cost ratio of an irrigation project, the difficulty of identifying this portion makes such a step impracticable. The difficulty becomes greater where a catchment area is common to more than one project. We suggest, therefore, that this cost element need not be taken into account in the economic appraisal of an irrigation project.

11.17 For calculating the benefit-cost ratio, we suggest that the following form should be adopted :

A. *Before introduction of irrigation*

(a) *Gross Receipts*
1. Gross value of farm produce.
2. Dung receipts at 30 per cent of the fodder expenditure.

Total gross receipts.

(b) *Expenses*
1. Expenditure on seeds.
2. Expenditure on manure and fertilizers.
3. Expenditure on hired labour (human and bullock).
4. Fodder expenses.*
5. Depreciation on implements.*
6. Share and cash rent.*
7. Land revenue.

Total expenses

(c) *Net value of produce*
Total gross receipts minus total expenses.

B. *After irrigation*

(a) *Gross Receipts*
1. Gross value of farm produce.
2. Dung receipts at 30 per cent of the fodder expenditure.

Total gross receipts.

(b) *Expenses*
1. Expenditure on seeds.
2. Expenditure on manure and fertilizers.
3. Expenditure on hired labour (human and bullock).
4. Fodder expenses.*
5. Depreciation on implements.*
6. Share and cash rent.*
7. Land revenue.
8. Interest on land levelling cost.

Total expenses.

(c) *Net value of produce*
Total gross receipts minus total expenses.

Net annual benefit = Difference in the net value of produce before and after irrigation, i.e. (B—A).

Annual Costs (1) Interest on capital @ 10 per cent.
(2) Depreciation.
(3) Administrative expenses.
Total : ————

$$\text{Benefit-cost Ratio} = \frac{\text{Net annual benefit}}{\text{Annual cost}}$$

*As a percentage of the gross value of produce.

Financing of Projects before Independence

11.18 In the early British days, irrigation works were looked upon as commercial ventures. Only such schemes were sanctioned as could pay for the annual expenses on maintenance and operation and meet the interest charges on the loan raised. A number of earlier schemes not only fulfilled these criteria but also made a net profit. This profit was not utilised to pay back the loan but credited to the general revenues; the loan remaining as a part of the standing public debt of the Province.

11.19 As a result of the great famine of 1877–78, the Government of India decided to set apart, every year, a sum of Rs. 15 million out of its revenues and credit it to a special fund for famine relief. The first charge on this grant was the actual cost of famine relief. Money not required for this purpose could be spent, in part, on the construction of protective railways and irrigation works, and the balance applied to the reduction of debt. The maximum sum to be devoted to protective railways and irrigation works was limited to half the grant, i.e.. Rs. 7.5 million. Later, it was decided that no part of the grant should be devoted to the construction of new railways. As a result, the full amount, i.e., Rs. 7.5 million, could be spent on protective irrigation works. In undertaking protective works, the direct return obtained from them by Government was a secondary consideration. These works were intended primarily for the protection of precarious cultivation.

11.20 From about 1867 to 1921, i.e., before the Montague-Chelmsford Reforms, all major irrigation projects were sanctioned by the Secretary of State and funds were provided by the Government of India from loans raised in London. Works were executed by the Provincial Governments and the expenditure was treated as an advance made to them from the revenues of India at a rate of interest fixed by the Government of India from time to time. After 1921, all productive irrigation projects were financed by State Governments, either from the general revenues of the State, or often from loans raised on government security. Such loans stood as a debt against the Government concerned till they were paid off by surplus revenues. The interest on the net loan was met yearly from the revenue budget, but the proforma administrative (capital and revenue) account of the project was debited yearly with the interest on the total sum-at-charge relating to it.

11.21 Unproductive and minor works have always been financed from general revenues of the Province concerned, or by grants from the Government of India.

Financing of Large Irrigation Schemes

11.22 Since India took to the system of planning, outlays for irrigation schemes have been met out of the overall Plan resources of States, which include, *inter alia*, revenue surpluses, State loans from the public and loans and grants from the Union Government. The State loans are not raised specifically for any irrigation or multipurpose scheme. Irrigation schemes have thus had to compete for Plan funds with development programmes in other sectors. During the first three Plans, in allocating Central assistance, some weightage was given to States with large irrigation schemes. But in spite of the weightage the full requirements of these projects could not be met. Also, in most cases, the cost of the projects had increased, partly due to the rise in prices and partly on account of under-provision in the estimates. The shortage of funds resulted in prolonging the construction periods, increasing interest charges and overheads, reducing financial returns and delaying the realisation of benefits.

In the Fourth Plan, after providing for the requirements of Assam, Nagaland and Jammu and Kashmir, the Central assistance to the remaining States is to be distributed to the extent of 60 per cent on the basis of their population, 10 per cent to States whose per capita income is below the national average, 10 per cent on the basis of tax effort in relation to per capita income, and 10 per cent in proportion to commitments in respect of major continuing irrigation and power projects. The remaining 10 per cent is to be distributed to States with certain special problems relating to metropolitan areas, floods, chronic drought and tribal areas. The weightage given to the continuing major irrigation and power schemes has eased their financial problems to some extent.

11.23 We wish to emphasise that once a scheme is taken up for implementation it must be constructed at an optimum pace determined by technical considerations, and the necessary funds must be provided for it. During our tours, a number of States informed us of the difficulties faced by them in accommodating large irrigation schemes in their Plans. They desired that the Union Government should assume special responsibility for financing such schemes. They did not wish the Union Government to construct, maintain or operate these schemes but only to finance them outside the normal allocation of the State Plans.

11.24 We have given the problem of financing large irrigation projects a good deal of thought, and have come to the conclusion that unless special arrangements are made for financing them it will not be possible to complete them speedily. Also, it is not in the best interests of the nation that when a State undertakes a very large irrigation scheme,

its other development activities should be slowed down. We would, therefore, suggest that at the time of according approval to a large irrigation scheme, irrigating, say, over two hundred thousand hectares, it should be examined whether the State Government is in a position to execute the scheme at the optimum pace, keeping in view its financial resources and its existing commitments to other schemes. If not, the State should negotiate with the Union Government for special financial arrangements for the scheme. In determining the nature of the special arrangement the following considerations could be kept in mind: the backwardness of the area to be served, the existence of large unharnessed water resources, which, in the absence of any special arrangement would take a long time to develop, and the ability of the State to undertake large projects. Central assistance in respect of such projects should be earmarked and funds made available to suit the actual requirement. The State should agree to execute the project expeditiously and efficiently. The need for special assistance for selected large irrigation projects is already recognised in the pattern of Central assistance to the States. What we are now suggesting is the extension of the principle, so that the full requirement of such projects is met, and not just a part of it.

11.25 Our attention has been drawn to the agreements now being concluded between the International Development Association (an affiliate of the World Bank) and the Government of India and the concerned State Governments regarding loan assistance for certain irrigation and multipurpose projects. These agreements make it obligatory for the concerned State Government to furnish information regarding the schedule of construction, water rates, progress of work, budget provision, etc. There is also a stipulation that if the schedules are not observed, the loan assistance may be withheld or terminated. We feel that such an arrangement in respect of projects which qualify for the special Central financial assistance suggested in the preceding paragraph, would be conducive to the timely and orderly execution of these schemes. We consider that the system of agreements or understandings, referred to above, would help in achieving these objectives and it would be worthwhile to introduce it.

Financing of Irrigation Schemes in Drought Affected Areas

11.26 In drought affected areas irrigation works are undertaken to ameliorate widespread suffering and to provide protection against recurring failure of crops. Projects in such areas are generally more expensive and irrigation is not as satisfactory as in areas with better water resources. The people of these areas are generally economically backward. Social justice, therefore, requires that they should receive special attention.

11.27 The Union Government has been advancing large sums of money by way of loans and grants to States for relief to drought affected areas. In addition to providing direct relief to the people, money is spent on rural works, such as minor irrigation schemes, roads, and moisture conservation measures. But only the dependable irrigation schemes provide permanent relief. Their completion directly reduces the amount that has to be spent on relief measures year after year. In order to promote early implementation of these schemes, we recommend that the Union Government should provide loans for them at a concessional rate of half the normal rate charged for irrigation schemes.

Financing of Minor Irrigation Schemes*

11.28 The financing of minor irrigation schemes such as wells, shallow and deep tubewells, small tanks, small canals in the hill areas, and lifting or pumping from rivers, nullahs, drains, etc., has presented little difficulty in the Plans. Many of these are private works for which loans have been made available, more liberally of late. Only those schemes which require sizeable investments, or which involved complex engineering techniques, like the sinking of deep tubewells, have been kept in the public sector. Increased provision has been made in the Plans for these schemes so that they can be implemented expeditiously. In the Fourth Plan there is a provision of Rs. 5,160 million in the public sector for such schemes. In addition, a sum of Rs. 6,500 million is expected to be made available from institutional sources, such as the Agricultural Refinance Corporation, Commercial Banks, etc., private investment is likely to be of the order of Rs. 3,000 million. We are satisfied with this substantial programme for minor irrigation works and the mode of its financing.

Financial Position of Irrigation Works

11.29 Prior to 1870, as we have already stated, irrigation works in India were treated as commercial undertakings. In 1880, a new category of unproductive irrigation works was introduced as a famine relief measure, and in subsequent years a number of such protective schemes were undertaken. However, irrigation works, productive and unproductive, continued to contribute annually to the general revenues. Immediately before Independence, a total area (excluding the Princely States) of 13.6 million hectares was irrigated by public irrigation works

*Irrigation Schemes costing less than Rs. 2.5 million in the plains and Rs. 3.0 million in the hills are classed as minor schemes.

in India, 11.4 million hectares by 'productive' and 2.2 million hectares by 'unproductive' works. In 1945–46, the 'productive' works provided the Government with a net profit of Rs. 90.6 million against a total capital outlay of Rs. 1,040 million and the 'unproductive' works showed a net loss of Rs. 11.4 million on a capital outlay of Rs. 450 million. Thus, the net gain to the exchequer, after meeting working expenses and interest charges was Rs. 79.2 million, the total investment being Rs. 1,490 million,* which worked out to a net profit of 5.3 per cent.

11.30 In 1947, the more productive irrigation works went to Pakistan. Those that were left in India yielded much lower revenues. Even so, they were financially remunerative. The position is shown in the table below :

Table 11.1
Financial Position of Irrigation Works, 1947

Area in million hectares
Profit in million rupees

Works	Post-partition India		Pakistan		Undivided India	
	Irrig. Area	Net Profit	Irrig. Area	Net Profit	Irrig. Area	Net Profit
1	2	3	4	5	6	7
Productive Works	5.6	19.10	5.8	71.50	11.4	90.60
Unproductive Works	1.6	(—)8.40	0.57	(—)3.00	2.17	(—)11.40
Total :	7.2	10.70	6.37	68.50	13.57	79.20

Source : Central Water & Power Commission.

Thus, immediately after Partition, irrigation works in India were making a net annual contribution to the exchequer of over Rs. 10 million.

11.31 Since Independence, there has been a progressive deterioration in the financial return from irrigation works. Instead of a profit, the works have been showing increasing losses and imposing a growing burden on the general revenues of the States. The ever-mounting losses for the country as a whole are shown in the table* below. The figures exclude 'Navigation, Embankments and Drainage', but include the irrigation component of multipurpose projects.

*Administration and Financing of Irrigation Works in India by N.D. Gulhati.

Table 11.2
Financial Return of public Irrigation Works

Area in million hectares
Amount in million rupees

Particulars	End of first plan 1955–56	End of second plan 1960–61	End of third plan 1965–66	1966–67	1967–68
1	2	3	4	5	6
Area irrigated	7.55	9.33	12.72*	12.87*	14.40*
Capital outlay	3,932.00	6,643.60	13,759.70	14,388.80*	15,181.40*
Accumulated interest	814.80	1,539.70	3,833.70	4,111.50	4,555.30
Accumulated revenue	1,348.60	1,502.50	1,859.60	1,734.80	1,947.70
Sum-at-charge	4,746.80	8,183.20	17,593.40	17,397.80	17,737.30
Gross receipts	160.90	223.50	348.50	319.40	370.40
Working Expenses	105.90	161.70	295.80	310.80	329.80
Revenue	55.00	61.80	52.70	8.60	40.60
Interest	103.40	206.60	588.60	577.70	606.50
Profit/Loss	(—) 48.40	(—) 144.80	(—) 536.00	(—) 569.10	(—) 565.90

*Provisional

11.32 Taking note of the deteriorating financial returns from irrigation works the Second Finance Commission (1957) observed that "a disturbing feature in the revenue position of most States was the deterioration in the net receipts from irrigation". The Commission had apprehended that sometime towards the end of the Second Plan period, i.e., 1960–61, when some of the projects would be completed, their impact on the revenue budgets would cause anxiety. The position has worsened considerably since.

11.33 Irrigation accounts are published annually by the Central Water & Power Commission (CW&PC) for 15 States. The remaining six States—Assam, Himachal Pradesh, Nagaland, Tripura, Manipur and Meghalaya—and the Union Territories do not have any sizeable irrigation works. It will be seen from Table 11.3 that in 1967–68 (the latest year for which published figures are now available) in seven States, namely, Gujarat, Jammu and Kashmir, Kerala, Mysore, Orissa, Uttar Pradesh and West Bengal, the gross receipts were so low that they did not cover even the working expenses. Except for Punjab and Madhya Pradesh, all the States incurred a net loss after discharging their interest liabilities. The State-wise position for that year is shown in Table 11.3.*

*Source : Central Water & Power Commission.

Table 11.3

Statewise Financial Returns of Irrigation Works for 1967–68

	Kilometres in operation		Area irrigated gross (million hectares)	Million rupees									
	Main canal & branches	Distributaries		Capital outlay	Accumulated interest	Accumulated revenue	Sum-at-charge	Gross Receipts	Working Expenses	Revenue	Interest	Net Profit	Net Loss
1	2	3	4	5	6	7	8	9	10	11	12	13	14
Productive and Unproductive													
Andhra Pradesh	5,054	14,854	1.398	1,144.40	509.00	417.00	1,653.40	50.50	25.30	...25.20	57.90	—	32.70
Bihar	—	—	—	98.10	120.50	53.70	218.60	27.10	22.60	... 5.50	4.70	—	10.20
Gujarat	1,508	2,388	0.228	1,162.50	402.50	—	1,565.00	6.30	8.30	— 2.00	55.20	—	57.20
Haryana	641	3,401	0.628*	175.00	2.80	176.50	177.80	14.30	8.30	... 5.90	7.90	—	2.00
J & K	616	832	0.099	49.20	30.10	—	79.30	0.70	2.30	— 1.60	1.70	—	3.30
Kerala	752	633	0.075	206.80	103.10	—	309.90	0.90	1.60	— 0.70	12.50	—	13.20
Maharashtra	3,669	4,706	0.345	1,489.00	366.60	42.20	1,855.60	22.60	9.90	...12.60	70.20	—	57.60
Madhya Pradesh	1,032	2,617	0.289	63.60	—	—	63.60	4.70	3.50	... 1.20	—	1.20	—
Mysore	2,358	4,878	0.284	1,091.60	333.40	—	1,425.00	5.20	13.40	— 8.20	47.00	—	55.20
Orissa	778	2,877	0.423	379.10	216.10	—	595.20	2.60	4.60	— 2.00	24.60	—	26.60
Punjab	1,368	8,297	3.041*	131.10	18.00	369.00	149.10	30.10	14.70	...15.40	5.30	10.10	—
Rajasthan	180	1,908	0.274	946.40	83.70	23.90	1,030.10	6.70	3.40	... 3.20	33.60	—	30.40
Tamil Nadu	5,534	10,077	1.222	920.60	424.50	79.90	1,345.10	18.70	15.00	... 3.60	47.90	—	44.30
Uttar Pradesh	7,208	37,539	4.073	2,285.90	1,001.60	785.50	3,287.50	163.70	164.90	— 1.10	102.60	—	103.70
West Bengal	—	—	0.040	31.00	52.80	—	83.80	2.40	3.20	— 0.70	1.60	—	2.30
Multipurpose	968	8,224	1.983*	5,007.10*	890.60	—	3,898.00	23.70	28.50	— 4.80	133.60	—	138.40
Total:	31,666	103,231	14.402*	15,181.40*	4,555.30	1,947.70	17,737.00	380.20	329.50	40.50	606.30	11.30	577.10

Note:—Statewise break-up of multipurpose projects is not available.
*Provisional.

11.34 At the time of Independence the existing irrigation works were, by and large, fully developed. The irrigated area under them had almost stabilised, with a steady revenue, but the balance sheet of the 'forties' showed a declining trend on account of higher maintenance and operation costs due to rising prices. Shortly after Independence there was a spurt in the development of irrigation, and several large schemes were taken up. Large investments were made on major and medium irrigation schemes—Rs. 3,000 million in the First Plan, Rs. 3,800 million in the Second, and Rs. 5,760 million in the Third—which took time to yield profits because of the fact that it takes some years for irrigation to develop fully after the completion of a scheme. During this time, with increasing investment not yet fully productive, interest liabilities began to mount. Some reduction in financial returns on this score was, therefore, only to be expected.

11.35 Several factors have contributed to the deteriorating financial returns from irrigation works. Their construction costs have greatly increased, as more and more expensive storage works with large dams had to be undertaken. Rising prices have also pushed up the cost of construction, maintenance and operation. Added to these have been the rising interest liabilities on investments not yet fully productive because of the lag in the utilisation of the potential created by new projects. All these required that the water rates should be raised to cover rising costs. But the State Governments, evidently for administrative and political reasons, have not raised the water rates adequately. This is not all. On some projects the irrigated area has fallen short of the targets envisaged in the project report, thus belying the expectations of revenue from these projects.

Financial Goal of Irrigation Projects

11.36 There is a view that irrigation projects should be undertaken not so much for the purpose of earning revenue but as a measure of social welfare, and that the irrigation rates should be kept low. This approach would be valid if the benefits from irrigation projects were, more or less, evenly distributed over the entire farming community. But this is not the case, as the main beneficiaries are only a section of the cultivators in the command area. It would be highly inequitable to call upon dry-farmers and the general tax-payer to pay for benefits enjoyed by irrigators. For this we have the powerful support of the First Irrigation Commission (1901), which commented that "*Prima facie*, there is no more reason for calling on the State, or, in other words, on the general tax-payer, to bear a permanent charge of, say, Rs. 6 per

annum, for the sake of increasing by irrigation the produce of an acre of land belonging to a private owner, than there would be for calling on it to pay a similar amount for the purpose of supplying another man's acre with manure". We are, therefore, of the view that irrigation works, as a whole, should give an annual income at least equal to their annual cost of operation and that no part of the burden for providing irrigation should fall on the general tax-payer.

11.37 The benefit which irrigation bestows upon a farmer in the drought affected areas is much higher than in other areas, as the difference in yield between irrigated and unirrigated crops is more in the former. With irrigation, farmers in such areas become as prosperous as their counterparts with similar facilities, elsewhere. In pre-1947 Punjab, the once barren districts of Lyallpur and Montgomery became the granary of India when canal irrigation facilities were provided. Much the same has happened in the Ganganagar area served by the Gang Canal in Rajasthan, and parts of Poona and Ahmadnagar districts which are served by the Deccan Canals in Maharashtra. We are of the opinion, therefore, that farmers in drought affected areas should also be charged normal irrigation rates based on the quality of service from the irrigation works.

Systems for Levying Irrigation Charges

11.38 There is considerable diversity in the systems for levying irrigation charges in different States. These systems have been replaced by local conditions and irrigation practices. In north India, irrigation works supplied water to a variety of crops raised on different fields and in different years. The irrigation requirement and the profit varied from crop to crop. Water charges on these irrigation works were, therefore, fixed on a crop-acre basis with different rates for different crops. The charges were recoverable from the irrigator and were known as the 'occupiers rate'. This system of charging for irrigation water is still in vogue in north India.

11.39 In south India, the major irrigation works built in the last century, namely, the Cauvery Delta Scheme, the Krishna Delta Scheme and the Godavari Delta Scheme, were primarily intended for irrigating rice, the single crop sown over the same area year after year. Here, it was found more convenient to combine irrigation charges with land revenue and to recover a consolidated amount. This arrangement reduced the assessment and collection costs. The system has remained in vogue ever since. For purposes of accounting, however, the consolidated

charges are divided into irrigation revenue and land revenue. For lands classified as 'wet', the irrigation charges formed from 68 to 84 per cent of the consolidated rate in different districts. There appears to be no scientific basis for fixing these percentages. On lands classified as 'dry', irrigation charges are levied in addition to land charges. On new projects, however, water rates are being levied and charged on a crop-acre basis.

11.40 In West Bengal, the deltaic region of Orissa, and parts of Bihar and Madhya Pradesh, where climatic conditions made it uncertain whether the cultivators would in any particular season take water or not, attempts were made to induce the irrigators to enter into leases for irrigation, which could be for as long a period as 10 years, or for a single season. Under this system, which still holds, lower rates were charged for long-term leases to serve as an incentive to farmers to enter into such leases.

11.41 In Maharashtra, up to 1905 the 'crop rates' system, i.e., charging a water rate on the basis of the kind of crop irrigated, was used. Subsequently, it was replaced by the 'seasonal rates' system in which all crops grown in the same season were charged at a uniform rate. An exception was, however, made in the case of sugarcane and other perennials because of the longer period for which they remained on the field, and their higher profitability. The rate structure was again modified in 1954, when a separate irrigation cess was introduced to cover the maintenance cost of the irrigation works. This cess is taken into account in fixing the 'crop rates' which again form the basis of water charges.

11.42 There is thus no uniform basis for irrigation charges. The conditions under which some of these systems originated have changed. For example, while rice is still a major crop in south India, cultivators there are also growing other irrigated crops such as cotton, ground-nut, jowar, etc., in the same area. A water-rate structure which had for its basis the irrigation of only a single crop, namely, rice, is, therefore, no longer valid. In recent years great progress has been made in the development of agricultural technology. This has a bearing on irrigation practices. There is, therefore, need for scientific enquiry into the prevailing irrigation rate-structure, so that it can be put on an equitable and rational basis. We now proceed to indicate the considerations which, in our opinion, should be kept in mind in determining the irrigation rate-structure.

Considerations in Fixing Irrigation Rates

11.43 Essentially, the value of irrigation is what it gives to the farmer

in the form of an additional profit. The irrigator is primarily interested in the net gain from irrigation and to him the cost incurred in making water available is of little consequence. His willingness to pay for water varies in proportion to the gain that he expects from its use. From the irrigator's point of view, therefore, water rates should be related to the benefit which irrigation confers rather than to the cost of irrigation projects.

11.44 The irrigation requirements of various crops are governed by a number of factors, such as climate, contribution from effective rainfall, if any, the level of the ground water table and the duration of the crop in the field. Because of these factors the requirement varies not only from crop to crop but also for the same crop grown in different seasons, such as the first, second or third crop of rice. Logically, therefore, the quantity of water supplied is also relevant.

11.45 Irrigation projects differ widely in their capacity to meet the irrigation requirement of crops. On projects with storage reservoirs, it is possible, ordinarily, to meet the full requirement of kharif crops, although there may be some difficulty in the pre-monsoon period. For rabi, the supplies vary from year to year. On projects with uncertain and fluctuating supplies, irrigation is less satisfactory and the irrigators have often to make do with fewer or shallower waterings. Then, there are areas with a precarious source of supply, such as drought affected areas which depend on tanks which fail in bad years. In such areas, proper crop planning and a resort to improved agricultural practices becomes difficult and in consequence yields are low. Adequacy and dependability of supply thus become important considerations in fixing irrigation rates.

11.46 Where irrigation rates are kept unduly low, irrigators are apt to use water carelessly and wastefully. On the other hand, a high rate may be burdensome to the cultivator and may discourage him from using available facilities. Such under-utilisation means less revenue to the Government and lower production for the farmer. Therefore, on canals which are under-utilised, a development rebate, which should be progressively reduced, would help to ensure fuller utilisation. Needless to say, there will always be some lag in the utilisation of water during the initial years after the completion of a project.

11.47 Water rates can, to some extent, influence the cropping pattern in a project area. It is possible to discourage the growing of a particular crop in an area by fixing a high water rate for it. Effective regulation of cropping patterns through water rates, however, is not feasible. But

even so, in fixing water rates for the different crops the State policy in respect of cropping needs to be kept in mind.

11.48 We have stated above that the value of irrigation water is the net gain which the farmer derives from its use. But irrigation is only one of the basic inputs used by a farmer and it is difficult to evaluate the precise contribution that it makes to his net gain. In view of this difficulty, the Maharashtra Irrigation Commission (1960–62) had suggested that water rates, on a crop basis, should be fixed between 6 to 12 per cent of the gross income, the gross income being easier to calculate. The higher limit of 12 per cent was suggested for cash crops and the lower one for food and fodder crops which have a lower profit margin. The 'Committee to Suggest Ways and Means of Improving the Financial Results of Irrigation Projects', appointed by the Government of India in 1964, had made a similar recommendation, but it had suggested a range of between 5 per cent and 12 per cent of the gross income. We generally agree with these recommendations and accept the range suggested by the Committee. This does not, however, apply to water charges on tubewells which are dealt with later on.

11.49 Water is a natural gift and a national asset. It is purely by accident that in certain areas the cost of providing water is low, involving little or no sacrifice or special effort on the part of the people of that area. These people, therefore, can have little claim to more favourable treatment in the matter of water rates. But all schemes do not give the same quality of service. Some provide dependable irrigation while others, like tanks in low rainfall areas, may fail altogether or provide inadequate or uncertain supplies in years of drought. Ordinarily, there should be no disparity in water rates between one project and another. But when there is a marked difference in the quality of service, there would be legitimate ground for differential rates.

11.50 With so many considerations involved, there can be no precise formula for the fixation of water rates, which must therefore remain a matter for administrative decision. As a guideline we recommend the following principles :

(i) Water rates should be levied on a 'crop basis', except in the case of irrigation from tubewells.
(ii) The rate should be related to the gross income from the crop and not to the cost of the project. It should range between 5 per cent and 12 per cent of gross income, the upper limit being applicable to cash crops.

(iii) The rates should be within the paying capacity of irrigators and should aim at ensuring full utilisation of available supplies.
(iv) Between regions with a similar class of supply, there should be the minimum disparity, if any, in the rates charged.
(v) For fixing rates, irrigation should be divided into A, B and C categories on the basis of the quantity and timeliness of supply. Lower rates may be fixed where, on account of good rainfall, the demand for irrigation water is less or where the supply is inadequate and uncertain.
(vi) The general level of rates in a State should be such that, taken as a whole, the irrigation schemes do not impose any burden on the general revenues.

11.51 Our recommendations in the preceding paragraph would require a substantial upward revision of the existing water rates in most States. We have already seen that the cost of irrigation per hectare varies widely from State to State. Because of the terrain and the nature of schemes, irrigation projects in peninsular India cost more than in the Indo-Gangetic plains. Recently, the CW&PC worked out the cost per hectare of major and medium irrigation schemes taken up during the Plans in various States. The results are shown in the Table 11.4.

It can be seen from the table that the cost on the continuing schemes is the highest in Kerala and amounts to Rs. 3,951 per hectare. The lowest cost for continuing schemes is in Haryana, followed by West Bengal. The average for completed schemes is generally lower than for continuing schemes. The cost of new projects is likely to be still higher.

11.52 In States of peninsular India where project costs are higher, on the assumption that the cost per hectare would be Rs. 2,500, the interest liability at the current rate of $6\frac{1}{2}$ per cent would annually come to Rs. 163 per hectare. To this should be added the cost of maintenance and operation, which is estimated at Rs. 15 per hectare. For covering these costs, the average water rate works out to Rs. 178 per hectare, which is roughly the price of a quintal of foodgrains. In States with cheaper projects, the water rates required for breaking even on annual cost would be somewhat lower. Considering the higher yields which are now being obtained from irrigated crops, the break-even rate for irrigation in practically all the States will be well within the limits of 5 to 12 per cent of gross income recommended by us for fixing water rates. These charges should not prove burdensome to cultivators, particularly in view of the fact that with the use of modern technology still higher yields are possible.

Table 11.4
Statewise cost in rupees per hectare of major and medium Irrigation plan schemes as of 31st March, 1970

State	Number of Schemes		Cost per hectare	
	Completed	Continuing	Completed	Continuing
1	2	3	4	5
Andhra Pradesh	33	21	1.016	2.721
Assam	—	5	—	1.067
Bihar	29	24	516	1.067
Gujarat	47	12	1.910	2.483
Haryana	3	6	*	507***
Jammu & Kashmir	4	3	1.273	3.417
Kerala	12	7	1,448	3,951
Madhya Pradesh	26	30	2.088	3,292
Maharashtra	44	41	2.365	3,514
Mysore	12	20	3.432	3,543
Orissa	—	15	—	1.559
Punjab	11	2	1,255	1,228
Rajasthan	44	15	1.320	2.642
Tamil Nadu	16	14	1,544	3.889
Uttar Pradesh	52	13	793**	1,189
West Bengal	4	5	806	1.055

Source:—Central Water & Power Commission.

*Bhakra Nangal project included under Punjab; benefits of the rest not given separately.

**Benefits of Bhander Canal have been included under Matatila Project in U.P. as no separate cost is available for the Scheme.

***Cost of Beas Unit I has been included in Haryana as no separate benefits have been given for Punjab, while that of Beas Unit II has been included in Punjab for the same reason.

11.53 For higher yields other inputs are, no doubt, necessary, such as seeds of high-yielding varieties, larger doses of fertilizers and pesticides, etc., but these can be successfully used only if adequate and timely irrigation supplies are available. In view of the key role of irrigation in increased production, there is full justification for levying adequate irrigation charges. We have little doubt that the farmer has the capacity to bear these rates.

During our tours, we came across several instances where cultivators were purchasing water at a price several times higher than canal rates, from owners of neighbouring tubewells or lift pumps. In Tikamgarh district, Madhya Pradesh, we found that pump owners charged Rs. three per hour for a 3 H.P. pump which supplies 0.25 ha. cm. of water. For a

10 cm. depth of water in the field, this means Rs. 120 per hectare per watering. Often pump-owners, there, sell water on a crop-sharing basis and take one third of the gross produce, which is still more expensive. A large part of the irrigated area in the country receives irrigation from privately owned sources and the farmers concerned incur heavy expenditure on irrigating their crops. The irrigation rates actually in force in different States are exceedingly low, as is evident from the table below, which shows the water rates for rice and wheat, the two most extensively irrigated crops, in the various States.

Table 11.5
Statewise Water Rates and Gross Value per hectare of Rice and Wheat

Crops	(a) Water rate per hectare (Rs.)	(b) yield per hectare (Kg.)	Harvest price at farm level (Rs. per quintal)	Value of produce per hectare (Rs.)	Percentage of column 2 to column 5
1	2	3	4	5	6
1. ANDHRA PRADESH					
Rice	37.5	1,428	98.44(c)	1,406	2.6
2. BIHAR					
Rice	37.5	926	59.63(c)	553	7.0
Wheat	22.5	940	87.02(c)	818	2.7
3. GUJARAT					
Rice	45 to 62.5	1,358	101.39(d)	1,377	3.2 to 4.5
Wheat	45 to 62.5	1,529	92.69(d)	1,417	3.1 to 4.4
4. HARYANA					
Rice	24.4	1,433	53.96(e)	773	3.1
Wheat	14.5	1,822	69.27(e)	1,262	1.1
5. KERALA					
Rice	12.5 to 25	1,447	107.56(c)	1,556	0.8 to 1.6
6. MADHYA PRADESH					
Rice	25	1,167	93.39(c)	1,090	2.3
Wheat	10 to 25	970	81.59(c)	791	1.2 to 3.1
7. MAHARASHTRA					
Wheat	22.5	626	123.47(d)	773	2.9
8. MYSORE					
Rice	40	1,474	74.09(c)	1,092	3.6
9. ORISSA					
Rice	2.5 to 20	1,171(f)	N.A.	N.A.	N.A.
10. PUNJAB					
Rice	24.4	1,326	53.96(c)	716	3.4
Wheat	14.6	1,953	69.27	1,353	1.1
11. RAJASTHAN					
Wheat	13.1 to 25	1,140	92.54(c)	1,055	1.2 to 2.3

Table 11.5—Contd.

(1)		(2)	(3)		(4)
12. TAMIL NADU					
Rice	40 to 50	1,517	73.79(d)	1,120	3.5 to 4.4
13. UTTAR PRADESH					
Rice	10 to 35	1,483	52.69(c)	781	1.2 to 4.4
Wheat	10 to 30	1,323	78.72(c)	1,041	0.9 to 2.8
14. WEST BENGAL					
Rice	13.4 to 31.25	1,824	128.32(c)	1,699	0.8 to 1.8

N.A.—Not available.

(a) Agenda notes for the Fifth Conference of State Ministers of Irrigation & Power (September, 1970).

(b) Ministry of Agriculture (E&S Directorate May, 1970), Relates to 1967–68.

(c) Relates to 1968–69 Agricultural Situation in India (August, 1970).

(d) Relates to 1967–68 Agricultural Situation in India (August, 1970).

(e) Punjab rates (1968–69) assumed, as figures for Haryana are not available—Agricultural Situation in India (August, 1970).

(f) Relates to 1966–67—E&S Directorate of Ministry of Agriculture (August, 1970).

These irrigation charges are a mere fraction of the gross value of the crop produced with the aid of irrigation. We recommend, therefore, that the States should review their irrigation rates and raise them suitably in accordance with the principles already enunciated by us. It might be mentioned that Maharashtra is already charging a rate of Rs. 445 per hectare for sugarcane and banana crops, and rates in Gujarat for these crops are nearly as high.

11.54 In canal commands, there are some areas which cannot be served by gravity flow. Cultivators carry out irrigation in such areas by lifting water, either manually or by means of a mechanical or electrical power device. It is a common practice to charge a lower rate, generally half, for irrigating such areas, in consideration of the extra labour or cost incurred in lifting water. Because of the extra effort or expenditure involved in lifting water, the irrigator takes care that water is used economically and wastage is reduced to a minimum. It results in a saving in terms of water of as much as 20 per cent. This, in itself, justifies a lower rate for lift irrigation and we recommend it. We would like to make it clear that our views run counter to the recommendation made by the Maharashtra Commission (1962) that, since the cost of providing water at a particular point is the same, whether the cultivator takes it by gravity flow or by lifting it, the charge for lift irrigation should be the same as the normal rate for flow irrigation.

Volumetric Assessment

11.55 Theoretically, the system of charging for water by volume, is the most scientific; but its application becomes practicable only if the measurement can be made at a point of supply to individual irrigators or to small groups of irrigators who can distribute the charges between them. In America, Australia and certain other countries, where farmers have extensive holdings, the system of charging for water by volume is practicable. But even there, the problem of interference with meters exists.

11.56 The Indian Irrigation Commission (1901–03) describes how Colonel Baird Smith, on his return to India as Superintendent-General of Irrigation in 1854, introduced a system of selling water by 'Paimana' or module, on the Ganges Canal. The Commission observed that "from the beginning it was a failure, as it was bound to be, even if the module had given accurate results: which it did not .... After a few years' trial the system was abandoned, and it has never since been restored".

11.57 The desirability of volumetric assessment was again suggested by F.W. Schonemann, Superintending Engineer in 1913 in his report to the Government of India after a visit to engineering works in France and Spain. The idea was tried in 1917 when a contract was entered into with a big farmer for the supply of water on a volumetric basis for an area of about 1,600 hectares from the Nanushahid Minor on the Lower Bari Doab Canal, now in Pakistan. Later, a few more big land owners accepted this mode of assessment. The results of several years of trial proved disappointing and the system did not catch on.

11.58 In India, where average holdings are very small, it is impracticable to supply water by measurement to individual farmers irrigating a variety of crops on an outlet. However, where sizeable areas are under a single crop, as in sugarcane blocks in Maharashtra or rice areas, the sale of water by measurement to co-operatives of irrigators becomes feasible. The Maharashtra Commission's Report refers to substantial economy in the use of water in sugarcane blocks where supply was being made on a volumetric basis. The Maharashtra Commission recommended that water, measured at the distributary head, should be handed over to a co-operative of irrigators on the distributary. The Government accepted this recommendation in principle, and agreed to supply water by measurement to co-operatives where at least 75 per cent of the irrigators agreed to become members. Three co-operative sugar factories on the Pravara canals undertook to take water by measurement and distribute it to their member-irrigators on a crop-area basis, but within a year,

they found the system to be unworkable for want of co-operation from the irrigators, and requested the Government to relieve them of this responsibility.

11.59 The Government of Gujarat also accepted the principle of volumetric supply to co-operatives of irrigators. But it has not found this system practicable. The reasons stated are the tampering with measuring devices by cultivators, the loss of head entailed in the process of measurement and the consequent loss of some command area on the outlet. No other State has yet introduced this system.

11.60 We are afraid that, on outlets serving a large number of irrigators, the volumetric system of assessment has not hitherto been successful. However, in another Asian country, Taiwan, the supply of water to co-operatives of farmers with small holdings on a volumetric basis has been eminently successful. We recommend, therefore, that efforts should be made to introduce the system in a few promising areas on a pilot basis. If the experiment is successful, it should be extended to other areas.

Assessment on Tubewells

11.61 Tubewell supplies differ in several respects from canal supplies. While canal supplies fluctuate and channels often remain closed for long periods, tubewells provide a steady supply, being less susceptible to the vagaries of nature, particularly in the alluvial tracts where most of the country's tubewells are located. In the case of canals, the annual working expenses remain the same, notwithstanding variations in the volume of water supplied. In the case of tubewells on the other hand, the cost of maintenance and power is related to the volume of water pumped. On tubewells, the water can be conveniently measured by means of a V-Notch, and this is less liable to interference by cultivators. This facility, and the high cost of pumping, make it desirable that tubewell water should be supplied by measurement.

11.62 In Uttar Pradesh and Madhya Pradesh, tubewell water is supplied to irrigators on a volumetric basis. The discharge of a tubewell is checked periodically by means of a V-Notch and the time for which the tubewell operates for each irrigator is noted, to determine the quantity of water supplied to him. In addition, the electrical units consumed during the period are recorded to provide a check.

11.63 In Haryana and Punjab, the supply of tubewell water is assessed

on the basis of electricity consumed in operating the tubewell for each irrigator, the argument being that electric meter reading is more dependable than the time-discharge basis of assessment, and that it also takes into account the head through which water is lifted.

11.64 We are of the view that it is more equitable to charge irrigators on the basis of the quantity of water supplied from a tubewell rather than the electricity consumed. Where charges are based on electricity consumed, the irrigator pays more per unit quantity of water when the supplies go down as a result of normal wear and tear, or inadequate maintenance, or a drop in the yield of the tubewell due to old age. Also, irrigators on tubewells with smaller lifts get an advantage for no effort or sacrifice on their part. We recommend, therefore, that tubewell water should be charged on the basis of the quantity of water supplied at the tubewell. Even in this case there would be some disparity in the amount which irrigators pay for areas located at different distances from the tubewell, because of transit losses; but with lined water courses and a proper roster of supply, the disparity can be considerably reduced.

Water Charges for Conjunctive Use of Surface and Ground Water

11.65 In Chapter V, we have pointed out the advantages of the conjunctive use of surface and ground waters. The conjunctive use may take one of the various forms described below :

(1) Pumped water from tubewells sunk along-side of a canal, as in Haryana, for augmenting canal supplies;
(2) Water from shallow tubewells sunk as an anti-waterlogging measure, put into irrigation channels, as in Punjab;
(3) Private tubewells or filter-points sunk in canal commands for irrigating crops when canal water is not available or is available inadequately;
(4) State tubewells sunk in a canal command to irrigate pockets which cannot be served with canal water;
(5) Tubewell water for a second crop and canal water for the first crop;
(6) Tubewell and canal water for irrigating the same area in a crop season.

11.66 In the first two cases, the canal supplies are augmented by ground water, and normal irrigation rates would naturally be applicable to areas irrigated by the channels, as the two waters cannot be separated, and the quality of service which these channels give is the same as from canal waters. In the third case, by sinking a private tubewell or a filter point the farmer derives additional benefit by irrigating his fields when

canal supplies are not available. Here, normal canal water rates should be charged where canal water is used for irrigation, but there should be no charge where the irrigator uses water only from his own source. In the fourth case, tubewell irrigation in the canal command is no different from tubewell irrigation elsewhere and obviously normal tubewell rates should be applicable. In the fifth case, the canal water rate should be charged for the first crop and the tubewell rate for the second crop irrigated with tubewell water. In the sixth case, both canal and tubewell charges should be levied. Had the tubewell not been installed, the irrigator would have paid canal rates for irrigating with the available canal water. On installing a tubewell, he derives an additional benefit by using tubewell water during periods of low supply when channels run in a roster. He can, therefore, confidently grow high-yielding and better quality crops, which other irrigators on the canal with an inadequate supply may not be able to grow. Therefore, a tubewell charge, in addition to the canal rate, would be justified on account of the increased production which he secures by the use of tubewell water.

Water Rates for Domestic and Industrial Supply

11.67 The bulk supply of water from irrigation systems for domestic and industrial purposes is generally made on a volumetric basis. The rates are fixed on an ad-hoc basis. A lower rate is charged for domestic use than for industries, which can bear a higher tariff. Water required for cooling purposes in industries and power stations is a different type of use in which only a part of the water supplied is consumed and the bulk is returned. Here there is a good case for fixing lower rates. However, in a closed-circuit cooling system the make-up water is put to consumptive use and should be charged accordingly. In Maharashtra, as a promotional measure, new industries are charged lower rates in the first four years. They are raised to the normal level in two steps. This, in our view, is a good arrangement. Water rates for industrial use should, as far as possible, be uniform throughout the State, or a region in the case of larger States, for the same category of industry, and should be related to the capacity of the industry to pay.

Promotional Water Rates

11.68 On the opening of a new irrigation system, supplies in the initial years are not quite satisfactory, as the running of channels is not free from trouble. Moreover, in areas where the cultivators are not used to irrigated agriculture, they are slow to make use of irrigation. They have to get familiar with irrigated cropping and have also to mobilise

the resources needed for irrigated farming. Therefore, as a promotional measure, it is generally desirable to charge lower rates in the initial three or four years, raising them gradually to full rates. In States where cultivators are keen on irrigation, promotional rates are not necessary.

11.69 At present, there is no uniformity in the levy of promotional rates in different States. Some States, like Madhya Pradesh, West Bengal and Mysore charge no water rate in the first year. Maharashtra charges no rate in the first year for food and fodder crops and only half the rate for other crops. In West Bengal, no charges are levied for rabi irrigation. While in most of these States full rates are charged in the fourth year, in Madhya Pradesh the period of concessional rate is unduly long—a quarter of the normal rate in the second year and half the normal rate during the next seven years.

11.70 We support the system of promotional rates on projects where cultivators are not familiar with irrigated agriculture and the demand for water is not keen. However, we consider prolonged concessions to be undesirable. They entail loss of revenue and accustom the irrigators to low rates which become more difficult to raise as time passes. In West Bengal, cultivators have not been accustomed to rabi irrigation because till recently not much rabi crop was raised. Rabi cultivation is now gradually gaining ground. While promotional measures for the irrigation of rabi crops are justified in this State, we consider that free irrigation need be given only for the first two years and thereafter water charges should be levied and raised gradually to the normal level.

Revision of Water Rates

11.71 The Uttar Pradesh Rates Committee of 1939 had recommended that water rates should be revised every five years, or earlier, if the general price level changes by more than 15 per cent. In 1959, the National Council of Applied Economic Research supported this view. The Maharashtra Commission in its report of 1962 suggested the revision of rates at intervals of six years. However, the Committee set up by the Government of India, in 1964, to suggest ways and means of improving financial returns from irrigation projects, recommended a revision every five years.

11.72 Taking 1960–61 as the base year with a price index of 100, the price rise in 'All Commodities' has been as below* :

Year :	1962	1963	1964	1965	1966	1967	1968	1969
Price Index :	104.2	108.0	119.3	129.1	144.5	166.2	165.3	168.7

*Indian Agriculture in Brief—Tenth Edition—p. 131.

The price rise in cereals, pulses and food articles has been steeper. With a 15 per cent change in price as the basis for a revision in water rates, as suggested by the Irrigation Rates Committee, Uttar Pradesh, there would have been at least three revisions in seven years. We feel that changing water rates at such short intervals would be administratively unworkable. In our view a five-year period for revision is appropriate.

11.73 It becomes difficult for a single State to take measures affecting large numbers of its people if there is no corresponding action by neighbouring States. In raising water rates, therefore, groups of neighbouring States must have a common policy. We may mention that after the re-organisation of Punjab, the unilateral suspension of the collection of betterment levy in Punjab in 1967, had given ground for legitimate dissatisfaction in areas of Haryana where collection was continued. Some of the States have suggested that the water rates and betterment levy should be fixed simultaneously in a region. We appreciate the force of the argument and recommend that water rates should be reviewed and revised by all the States in the fourth year of every Plan. This would also help the Planning Commission to assess the resources of the States for the next Plan more accurately.

Betterment Levy

11.74 The betterment levy, through which the Government claims a share of the unearned increase in land values as a result of irrigation, is not new to the country. A betterment tax was levied in the Princely State of Mysore as far back as 1888. The levy was fixed at one-third to one-half of the difference between the local market values of an acre of unirrigated and an acre of irrigated land. Years later, when the Thal Canal Project (now in Pakistan) was taken up in the 1930s it was decided to levy a betterment fee of Rs. 30 per acre. After Independence, a betterment fee was strongly recommended in the First Plan and the States were advised to promote the necessary legislation to enable them to levy it on all new projects.

11.75 The Taxation Enquiry Commission (1953–54) supported this measure, and recommended that the amount should be limited to 50 per cent of the increase in the value of land and that the recovery should be made over a reasonably long period. Emphasising the need for and the desirability of the levy, it was recommended in the Second Plan that "it is equitable that beneficiaries from tubewells and such other minor irrigation works which provide secure irrigation are also included in the scope of legislation and required to pay betterment contribution".

11.76 All the States have enacted legislation for raising this levy, with the exception of Uttar Pradesh. West Bengal and Jammu & Kashmir did not feel the necessity for an enactment as the levy was covered by other existing Acts. Different States, however, adopted different criteria for the levy. Broadly, the quantum of levy was determined by one or more of the following criteria :

(i) Increase in the market value of land benefited between the date of commencement and the date of completion of the project, as in Maharashtra.
(ii) Difference between the market value of irrigated and unirrigated land in the project area or in its vicinity, on completion of the project, as in Mysore, Rajasthan and the Telangana area of Andhra Pradesh.
(iii) Increase in the value of land equated to a multiple of the increase in the value of agricultural produce in a year on completion of the project as in Orissa and Kerala.
(iv) Recovery of a portion of the capital cost of the project, as in Punjab.

In all these Acts, the proposed recovery formed only a portion of the unearned benefit. A number of States, like Andhra Pradesh, Maharashtra, Mysore, Orissa, Punjab, and Rajasthan stipulated that land holders could pay the levy in the shape of land, if they so wished.

11.77 Most of the Betterment Levy Acts stipulated that the recovery could be in one lump sum or spread over a period not exceeding a prescribed number of years. Andhra Pradesh, Kerala, Tamil Nadu and Mysore stipulated a maximum of 20 years, while Madhya Pradesh, Punjab and Bihar prescribed a period of 15 years, and Orissa 16 annual instalments. In different States, the levy was to commence two, three or four years after the introduction of irrigation in the project area. The levy was chargeable on irrigable lands whether the facility was actually availed of or not.

11.78 The Acts, however, have not been implemented by most of the States, and in some not even an assessment has been made, let alone any recovery.

11.79 The main obstacle in enforcing the Betterment Levy Act has been the difficulty in assessing the increase in the value of land as a result of irrigation. It is contended that tenancy laws conferring permanent ownership rights upon tenants, and the implementation of other land reform measures, such as the abolition of intermediaries, fixation

of fair rent, ceilings on land holdings, regulation of transfers to prevent fragmentation of holdings, have all affected the market value of land. Hence it becomes difficult to assess the increase in land prices attributable to irrigation. This adds to procedural difficulties and causes delay in the enforcement of betterment levy laws.

11.80 In view of the massive investment of Rs. 21,300 million made since 1947 on irrigation works, and the very large programme recommended by us in Chapter X, which is likely to cost Rs. 100,000 million, the future development of irrigation is likely to be retarded unless financial resources are mobilised.

11.81 There is, in our view, every justification for realising part of the capital required for future projects from those who benefit from irrigation works. This is best done in the form of a levy on lands which benefit from irrigation. As the existing laws for betterment levy have run into procedural difficulties because of the levy being based on the increase in land values or in crop production, we consider that a change in the basis of assessment is called for.

We recommend, therefore, that betterment levy laws enacted by the States should be amended so that half the capital cost of the irrigation projects is recovered from the beneficiaries. The recovery of the levy should start three years after irrigation is provided in an area and it should be spread over a long period but not exceeding 30 years in order to avoid the imposition of too heavy a burden on irrigators. The scale of levy would naturally vary from project to project, being a function of the cost of providing irrigation per hectare. Where beneficiaries have already paid part of the levy due from them, their future liability should be adjusted to allow for payments already made.

Measures for Improving Financial Position of Irrigation Works

11.82 In order to improve the financial position of irrigation works, three major steps are necessary. Firstly, every effort has to be made to fully utilise the irrigation potential of new projects in as short a time as possible. It is obvious that the quicker the development of ayacuts on new projects, the larger would be the revenue recovered in the development stage and the less would be the sum-at-charge. Secondly, every attempt has to be made to secure the maximum irrigation from the available supplies by avoiding wastage of water and making maximum use of it through good water management practices. This is important not only to secure larger revenues, but also to promote the best utilisation of our scarce water resources. Thirdly, water rates should be fixed at

such a level that irrigation projects are not a burden on general revenues, except for unproductive projects in scarcity areas.

Economic Review of Large Projects

11.83 Huge sums are spent on the larger irrigation projects with the expectation that they will confer corresponding benefits. Besides the revenues they yield, their contribution to the economic growth of a State is even more significant. It is, therefore, important that there should be an economic review of such projects to assess the extent to which expectations have been fulfilled and to locate the causes for the shortfall, if any. A review of this nature can be of great help in identifying problems and in evolving measures which would further improve the utility of the project. For instance, a review may reveal the need for a change in the cropping pattern or a modification in the operation of the water delivery system. Thorough economic reviews of some of the larger irrigation and multipurpose projects have already been made and have proved their utility. Of these, mention might be made of the studies of the Bhakra-Nangal project, the Sarda Canal, the Ganga Canal, the Hirakud project, the Tribeni Canal, the Damodar Canal and the Cauvery-Mettur project. The National Council of Applied and Economic Research, Delhi, the Gokhale Institute of Politics and Economics, Poona, the Institute of Economic Growth, Delhi, and several universities and other research organisations have taken keen interest in such studies and their services can be availed of in making studies of more projects. We recommend that economic reviews of every large irrigation project should be made after achieving a reasonable degree of utilisation in, say, 5 to 10 years of its operation.

CHAPTER XII

ADMINISTRATION AND ORGANISATION

The massive programme for the development of the country's water resources, as indicated by us in Chapter X, calls for a streamlining of the procedures and agencies dealing with irrigation both at the Centre and in the States.

12.2 Several major tasks lie ahead. The investigation and exploitation of ground water and its conjunctive use with surface water, needs special attention. The basin-wise studies envisaged under the River Boards Act have not been undertaken. Greater coordination at the highest level between the Union and States has to be established, so that national policies can be formulated and implemented. The development of ground water resources, at present the responsibility of more than one department, at the Centre and in the States, needs to be integrated.

12.3 In this Chapter, we propose to deal with the procedures, institutions and administrative systems needed at the Centre and in the States to cope with the challenges of the next 20–30 years.

Organisation for Assessment of Water Resources

12.4 At present, the assessment of the surface and ground water resources of the country is done at several levels and by several organisations.

At the Centre, the Ministry of Irrigation & Power undertakes observations in the Ganga basin through the Ganga Basin Water Resources Organisation, while the Central Water & Power Commission (CW&PC) does the same for the Krishna, Godavari, Mahanadi and other rivers. In the States, gauging stations have been established to provide data for State projects. There is no central organisation for the country as a whole for the compilation, collation and publication of hydrological data. Whatever data is collected by the States is maintained for their own purposes, and is not published by one authority, or in one place. Some data is not published at all. So far, efforts to collect data relating

to surface water resources in an integrated and comprehensive manner have not met with much success.

12.5 Approximate estimates have been made of the ground water resources of the country. These are largely based on general observations and the available data. Here again, there are several organisations involved. At the Centre, along with mineral prospecting, the Geological Survey of India (GSI) has been prospecting for ground water through its Ground Water Division. The Exploratory Tubewell Organisation (ETO) (now renamed the Central Ground Water Board) in the Union Ministry of Agricultulture, has undertaken a series of local tubewell borings. A number of States have their own organisations for exploiting ground water through shallow and deep tubewells.

12.6 The division of water resources into surface and ground water is merely a technical convenience for purposes of categorisation. In planning for the exploitation of these resources there can be no watertight compartments. The dynamism which characterises the hydrological cycle necessitates the integration of all data relating to the cycle, and of all studies based on this data. In particular, the conjunctive use of ground and surface water makes this integration imperative, particularly at the stage of planning. However, the present system of data collection for the planning and development of water resources does not adequately recognise this inter-dependence. For this reason, these resources have not been harnessed to the best advantage.

Directorate of Hydrology

12.7 As a first step towards integrating work connected with the assessment and development of the country's water resources, we recommend the setting up of a Directorate of Hydrology under a Director-General. The functions of the Directorate will be :

(i) The collection of gauge discharge and sediment data for all major rivers and their tributaries at key gauging stations;
(ii) the promotion of work for preparing longitudinal and cross-sections of rivers;
(iii) the standardisation and improvement of methods and procedures for the collection and assessment of hydrological and sedimentation data; and
(iv) the periodical publication of hydrological data.

12.8 We recognise that much of the work relating to the collection of data will continue to be done in the States. However, the Directorate

in addition to its other functions, will co-ordinate the efforts of all agencies dealing with the collection of data in the States and at the Centre, so that these efforts are complementary. It will guide and advise the States in framing programmes for the collection of data, and in achieving a high level of accuracy. The role of the Directorate vis-a-vis the States, in the matter of collecting accurate hydrological data, will lend strength to the River Basin Commissions which we are recommending, later in this chapter, as organisations responsible for preparing Master Plans for river basins.

12.9 The Ganga Discharge Circle, which is at present under the Ministry of Irrigation & Power, the Central Gauging Circle and the Central Discharge Circle under the CW&PC, should be transferred to the Directorate to form the nucleus of the new organisation. Since the cadre of the Directorate would be relatively small, the chances of promotion in it will be limited. The question of integrating the cadre with that of the CW&PC should, therefore, be examined.

The Directorate should be attached to the Ministry of Irrigation & Power.

12.10 The composition of the Directorate should be as below :

A Director-General of the rank of a Member, CW&PC, assisted by:

(i) Director of Hydrological Studies; and

(ii) Director of Publication.

There should be a field organisation headed by a Chief Engineer with four Circles located at suitable places in the country.

Organisation for Ground Water at the Centre

12.11 Ground water development generally falls in the category of 'minor' works. These works may be further classified as :

(i) Deep tubewells, which require expertise in construction and maintenance and are largely owned by the State, and

(ii) Dug wells, shallow tubewells and filter points which are simple structures privately owned, for the most part.

At the Centre, the work of prospecting, exploration, mapping and development of (i) above has recently been vested with the Central Ground Water Board (CGWB) under the Ministry of Agriculture. Financial assistance to the States for 'minor' works pertaining to (ii) above is also co-ordinated and processed by the Ministry of Agriculture.

12.12 Systematic prospecting, exploration and mapping of deep aquifers and their development started in 1954, when a Ground Water Division was set up in the GSI and the ETO in the Union Ministry of Agriculture. The functions of the two bodies were clearly laid down. The GSI was given the responsibility of conducting geo-hydrological reconnaissance and geo-physical prospecting. The lithological and sedimentological information collected by its field staff was mapped and passed to the ETO for the development of ground water through deep tubewells.

12.13 The aforesaid division of functions continued till recently when the Union Government took a decision to transfer the work of prospecting, exploration and mapping of deep aquifers from the GSI to the CGWB.

12.14 The grounds for this transfer are stated to be as follows :

(a) that at the rate at which systematic survey and hydrological mapping was being done by the GSI, it would need a period of 30 to 50 years to survey the whole country;
(b) that of the 1,000 geologists working in the GSI, only 80 or so had been employed on prospecting for ground water, which indicates that the work accounts for only a small portion of the GSI's total responsibility; and
(c) that if the objective of covering the worst drought affected area within a period of five years was to be met, the GSI would have to undertake a very substantial expansion of its ground water programme and that such an expansion was unlikely as long as the GSI's main concern was with minerals and so long as it remained part of a Ministry in which ground water figured as a marginal activity.

12.15 We have given serious thought to these grounds and regret that, in our opinion, they do not bear scrutiny. The GSI is after all only a department of the Union Government and if it is given a specific task by the Government to be completed within a specified period, there is no reason to suppose that the GSI would not carry out the task, if adequate staff and funds are provided. We are of the opinion that the GSI is the most suitable organisation to handle the work involved in prospecting for ground water resources. It is the highest scientific and technical organisation in the country dealing with ground water exploration as a part of its normal functions. During the past 100 years, it has acquired specialised scientific and technical expertise, and has built up a large

and highly qualified body of officers whose specialisation is geology. By virtue of their specialised knowledge and long experience, these officers can give the required backing to the work of the field geologists and can interpret and correlate their findings. There is no comparable organisation in the country which has the necessary expertise and the geological, geo-physical and other specialised equipment for ground water prospecting. Its laboratories, libraries and sophisticated instruments are naturally available to the geologists engaged in prospecting for and mapping ground water resources. In the circumstances, we feel that it would be a retrograde step to dissociate the GSI from the work of ground water prospecting. We also feel that it would be unwise to transfer ground water geologists from the GSI to the CGWB which has no experience in the field of geological prospecting and, therefore, will not be able to give them adequate guidance.

We, therefore, recommend :

(i) that the decision to transfer the prospecting, exploration and mapping of ground water from the GSI to the CGWB should be reviewed, and that the status quo should be restored;

(ii) the GSI should be directed to complete the prospecting and mapping of the country's water resources within a specified period and adequate staff and funds should be made available to it for the purpose; and

(iii) the CGWB should continue to perform all the functions entrusted to it excluding those which have hitherto been the responsibility of the GSI.

12.16 The Committee on Plan Projects in the Planning Commission, in June, 1966, observed that "if the subject of irrigation in all its aspects is dealt with by one Ministry in the Centre and by one Department at the State level, it may result in a more wholesome programme for the development of irrigated agriculture". Dealing with the same issue, the Study Team of the Administrative Reforms Commission in its report on the 'Machinery of the Government of India and its Procedure of Works', suggested that "the development of ground water resources should be transferred from the Ministry of Food & Agriculture to the Ministry of Irrigation and Power". To quote the Team, "The definition of minor irrigation should be reviewed to ensure that the Department of Agriculture is not burdened with projects having a substantial engineering content, particularly so in the projects exploiting ground water resources and that the ETO should be transferred to the Ministry of Irrigation & Power".

12.17 The Commission has given most anxious thought to this matter. It is of the opinion that inter-related activities are best performed under the supervision and control of a single authority. As we have already discussed, surface and ground waters are interdependent components of the hydrological cycle. Ground water has its source in surface flows, either in the shape of percolation of rain water or of seepage from streams and canals or percolation from irrigated areas. Likewise, the flow of water in many streams in the dry season is contributed by ground water regeneration. There is, thus, a positive inter-connection between surface and ground water. With the construction of irrigation works, changes take place in the hydrological regime which, some times increase the danger of waterlogging. Waterlogging can most effectively be dealt with by extracting water through tubewells for irrigation and as a means of controlling the water-table.

12.18 Modern planning of river basins has to be on the basis of the totality of the available surface and ground water resources in the basin. The concept of the integrated use of surface and ground water is now universally recognised. It would be incorrect and even harmful to allow them to develop in isolation.

12.19 Ground water exploitation through tubewells involves constant research to improve the efficiency of tubewells and to prolong their operational life. With tubewells having to be replaced every 15–20 years, considerable expenditure would be saved if the working life of a tubewell could be extended. Furthermore, extensive hydrological and other experiments are necessary to achieve a safe optimum level of withdrawal from aquifers. There are a number of research stations under the Ministry of Irrigation & Power, manned by experienced engineers and scientists which could handle all the research problems connected with the exploration and development of ground water.

12.20 In view of the considerations mentioned above, we suggest that the exploration and exploitation of ground water through heavy duty tubewells should be undertaken by the Ministry which deals with surface water. In our opinion, the Ministry of Irrigation & Power is best equipped to deal with the technical, scientific, economic and administrative problems involved in the exploitation of ground water and we would, therefore, recommend that the CGWB should be transferred to the Ministry of Irrigation & Power from the Ministry of Agriculture.

12.21 We recognise that what might be called on-farm utilisation of ground water for agricultural purposes is clearly within the purview and

competence of the agriculture department. The exploitation of ground water through percolation wells does not involve much engineering skill and it should appropriately continue to remain under the Ministry of Agriculture. We also do not visualise or recommend any change in the present arrangement for financing private enterprise in the field of ground water development, which should continue to be handled by the Ministry of Agriculture at the Centre.

Preparation of Basin Plans

12.22 In Chapter V we have explained in detail why river basin plans should be prepared. Here we propose to describe the machinery needed for the purpose.

River Basin Commissions

12.23 To prepare basin plans, we propose that River Basin Commissions be set up. These Commissions will have the following functions :

(i) To compile and analyse, basinwise, hydrological data collected by the Directorate of Hydrology and other agencies;
(ii) to compile and analyse, basinwise, geo-hydrological and other ground water data;
(iii) to prepare basin plans; and
(iv) to deal with any aspect of water resources development entrusted to it for study by the Union Government or the National Water Resources Council.

12.24 As we have already said, each river basin has its own peculiar characteristics and, therefore, as many river-basin plans as there are major rivers in the country, will have to be prepared. The number of such plans may work out to 20 or more. Since this will be too much for a single Commission to handle, we are of the opinion that the number of River Basin Commissions in the country should be seven. They would be as follows :

(1) *Western River Basins Commission*
covering the Narmada, the Tapi, the Mahi, the Sabarmati, the Banas and their tributaries.

(2) *The North-West River Basins Commission*
covering the Ravi, the Beas, the Sutlej and their tributaries.

(3) *The Upper-Ganga River Basin Commission*
covering the main Ganga up to its confluence with the Yamuna and including its tributaries up to that point.

(4) *The Lower-Ganga River Basin Commission*
covering the main Ganga from its confluence with the Yamuna to its outfall into the sea, and all its tributaries from the north and south below the confluence.

(5) *The North-East River Basins Commission*
covering the Teesta, the Brahmaputra, the Barak and their tributaries.

(6) *The Eastern River Basins Commission*
covering the Mahanadi, the Brahmani, the Baitarni, the Subarnarekha and their tributaries.

(7) *The Southern River Basins Commission*
covering the Godavari, the Krishna, the Penner, the Cauvery and their tributaries.

12.25 It may not be necessary to appoint all seven Commissions at the same time, since the apportionment of the water of some major rivers like the Narmada, the Godavari and the Krishna, is under dispute before tribunals. We are of the opinion that, to begin with, four Commissions may be appointed. The work of Commissions (1) & (2), (4) & (5) and (6) & (7) can be combined to begin with, and later, as work increases, they can be split as envisaged in the previous paragraph.

12.26 We recommend that each Commission should have four whole-time members; two senior engineers, an economist specialising in agricultural economics, and an agronomist, all of them nominated by the Union Government. One of these members will be nominated as Chairman by the Union Government. Each State Government concerned with the basin will nominate one of its Chief Engineers as a part-time member. Smaller States and Union Territories may be grouped for being given representation by rotation.

12.27 The river basin plans prepared by the Commissions will be sent to the States for their opinion, and, thereafter, the plans along with the views of the States and the comments of the Commission, if any, will be submitted to the National Water Resources Council. Thereafter these plans will be forwarded to the States and the Union Government for implementation.

Water Resources Council

12.28 Considering the vastness of the country and the existence of about twenty major river basins; the need for the conservation, utilisation and inter-basin transfer of the nation's most vital natural resource, of which almost 9/10th is used for irrigation; and of laying down priorities for the use of water as between irrigation, power generation, industrial and domestic purposes etc., the Commission has no doubt in its mind that there is a necessity to set up an apex body to frame national policies and to take appropriate decisions for the utilisation of the country's water resources. This body will keep a continuous watch on the working of the River Basin Commissions and problems of inter-State rivers and ensure that the formulation and execution of irrigation projects conform to the highest national interests. We, therefore, recommend that a body, to be called 'The National Water Resources Council' be set up for the country.

12.29 Our proposal finds support from what is being done in some other countries. In the United States of America, the Water Resources Planning Act of 1965 established a Water Resources Council to carry out the policy of the United States as set forth in the Act "to encourage the conservation, development and utilisation of water and related land resources—on a comprehensive and co-ordinated basis by the Federal Government—States and private enterprises with the co-operation of all affected federal agencies; to maintain a continuing study and to prepare periodical assessment of the adequacy of supplies of water necessary to meet the water requirements for each water resources region in the United States and of the national interest therein; to maintain a continuing study of the relation of regional or river basins plans and programmes to the requirements of large regions of the Nation; to establish, in consultation with appropriate inter-State, federal and non-federal bodies and with the approval of the President, principles, standards and procedures for federal participation in the preparation of comprehensive regional or river basin plans, and for the formulation and evaluation of federal water and related land resources projects, etc. etc." The same Act provides for the establishment of Federal-State River Basin Commissions, the field agencies whose functions are "to serve as a principal co-ordinating agency for plans for water and related land developments; to prepare and keep up to date a comprehensive plan for water and related land resources development within the basin; to recommend priorities for data collection for financing, planning and construction of projects".

The first National assessment prepared by the U.S. Water Resources Council was published in November, 1968.

In Australia, which also has a Federal Constitution, a ministerial level Water Resources Council has been established by common agreement between the Commonwealth and all State Governments to provide "a comprehensive assessment on a continuing basis of Australia's water resources, and extension of experiments and research, so that future planning can be carried out on a sound and scientific basis".

12.30 The proposed National Water Resources Council would be the highest national policy-making organisation for irrigation in the country, and would, (i) lay down broad technical, economic and financial policies in irrigation for the country as a whole, in relation to inter-State rivers and river valleys; (ii) suggest priorities for the accelerated development of the water resources of each region and priorities for the use of water; (iii) define possibilities of importing water from or exporting water to another basin, i.e., the transfer of water from surplus to deficit areas; (iv) evolve formulae to evaluate costs and benefits when sanctioning river basin projects; and (v) review basin plans prepared by River Basin Commissions, prior to sending these plans to the Union Government and to the States.

12.31 We have given careful thought to the composition of the Council. As the highest national body dealing with water resources, it will be called upon to play a vital role in a most important sector of the country's economic development and should enjoy a position of prestige. We would recommend that the Prime Minister of India should be the Chairman of the Council and the Union Minister for Irrigation & Power, its Vice-Chairman. The Ministries of Finance, Agriculture, Community Development, Planning, Health, Industry and Tourism, should be represented on it through their Ministers. Major States should be represented on the Council either by their Chief Ministers or by Irrigation Ministers. The smaller States and Union Territories could have group representation, by rotation.

12.32 We would further recommend that two eminent irrigation engineers and the Chairman, CW&PC, should be members of the Council.

12.33 The CW&PC will act as the Secretariat of the Water Resources Council.

12.34 We recommend that the National Water Resources Council and the River Basins Commission should be created by an act of Parliament. Entry 56 of List I of the Union Constitution empowers Parliament to legislate for the regulation and development of inter-State rivers and

river valleys in the public interest and there would be no constitutional difficulty in the way of this legislation.

12.35 Although we may, perhaps, be marginally exceeding our brief, we would recommend that in order to enable the Ministry of Irrigation & Power to play its role as the custodian of the country's most valuable natural resource, the Minister in charge should be a Member of the Cabinet. Some State Governments expect the Centre to handle major irrigation and power problems. They expect it to define broad irrigation policies, regulate inter-State rivers and river valleys and participate in the management of inter-State projects. We hope that our recommendation will strengthen the Irrigation & Power Ministry and the National Water Resources Council and place them in a better position to deal with inter-State differences and disputes.

Other Administrative Matters in the Union Government

12.36 For some time there has been a controversy over the place of the generalist and the technocrat in technical departments of the Secretariat. Those favouring the generalist claim that the technocrat often suffers from the effects of specialisation which, according to them, tends to narrow his vision and restrict his range of thinking. The opposing view, in favour of the technocrat, is that the education and training of the generalist does not qualify him to advise Government in the person of his Minister on technical matters. It is also argued that the generalist has to be continuously briefed with regard to simple technical matters and this creates delay.

12.37 The Administrative Reforms Commission while examining this problem has in its report on 'Personnel Administration' opined as follows :

> "In the constitutional set-up which we have, with equality of opportunity guaranteed, it is not possible to sustain monopoly and reservation for one or other class of government servants. The road to the top must be open to every competent and qualified government servant. To higher management in the Secretariat, talent must be drawn from every cadre and class of government servants".

12.38 We have considered the suggestion that the Secretary of the Ministry should be a technical officer. Since the Ministry of Irrigation & Power is not an executive body, but a department of the Union Govern-

ment Secretariat like others, we are of opinion, that it should be regulated by the normal rules of business governing such departments. The Minister in charge of the department has to have at his disposal material and advice pertaining to administration and finance on the one hand, and technical matters on the other. Obviously, it is necessary that the Ministry's business should be so ordered that in predominantly or wholly technical matters, the Minister is guided by the advice of a technocrat and where matters concern administration, finance or policy, he is guided by the advice of the Secretary, be he an administrator or a technocrat. Implicit in such an arrangement is the convention that the Secretary is free to seek the advice of his technical colleagues in the Ministry even in matters which are predominantly or wholly administrative. This arises from the fact that there can be no clearly defined line between matters which are technical and those which are not. It is for the Government, therefore, to decide in the particular circumstances of each situation whether the Secretary should be an administrator or an engineer.

Secretariat status for CW&PC Chairman

12.39 To ensure that the advice of the CW&PC on technical matters is directly available to the Minister of Irrigation & Power, we recommend that the Chairman of the CW&PC should be made ex-officio Special Secretary in the Ministry. If this is done the Minister can have technical advice direct from the highest technical body, and from his Secretary on financial and administrative matters. The Secretary of the Ministry, as the Head of the Secretariat may also seek the advice of the Chairman, CW-&PC, whenever he feels it to be necessary. A convention can always be established that matters which are directly referred by the Chairman of the CW&PC to the Minister should also be brought to the notice of the Secretary.

12.40 At present, the CW&PC is an attached office of the Ministry of Irrigation & Power. In practice, this means that whatever proposals it makes, whether technical or administrative, have to be channelled through that Ministry. In routine matters of no special importance, this system works fairly well. However, it becomes unsuitable in cases involving highly technical matters. Apart from the advantage of allowing the Chairman, CW&PC direct access to the Minister, we feel that conferring a high Secretariat status of a Special Secretary on him will also assist him in approaching Secretaries of other Ministries, such as Finance and Agriculture, whenever it is necessary to speed up matters.

Investigation and Planning in States

12.41 In the States, there is a general recognition of the importance of hydrological data and of sound investigations prior to the sanction of projects. Practically all the major States have already created organisations for this purpose. In some, like Madhya Pradesh, Maharashtra, Mysore, Gujarat etc., the organisations have been put under a separate Chief Engineer while in others this work is looked after by Chief Engineers who handle construction work.

12.42 A close liaison between the investigating organisations in the States, and the Central agencies, such as the Directorate of Hydrology and the CGWB has been stressed earlier. This would ensure that the State organisations are made aware of the latest techniques, and that uniform standards in methods and procedures are adopted.

12.43 In order that the agronomical aspects of an irrigation scheme receive full attention from the very beginning of project planning, we consider it important that in big States with large programmes of irrigation development, a separate unit in the State Agriculture Department should be established to devote its whole time attention to the cropping patterns, intensities and water requirements of crops.

Ground Water Organisation in States

12.44 The direct responsibility for all aspects of ground water development rests on the State Governments. The Central organisation can only lend support in the evaluation of the resource by laying down standards and processes for the collection and measurement of data. The Central organisation can also assist in shaping policy for integrated development and conjunctive management of the total water resources in a basin and in matters such as the design of tubewells and training of personnel.

Thus the need for the States to provide themselves with suitably staffed and properly equipped organisations is imperative.

12.45 Under the existing arrangements ground water development in some States is handled partly by the Irrigation Department and partly by the engineering wing of the Department of Agriculture. The Irrigation Department carries out assessment studies for ground water and also constructs, operates and maintains State tubewells. The Agriculture Department provides drilling and boring facilities for private tubewells and for open wells, and handles their financing programmes.

12.46 The pattern of organisation for ground water development in the States is anything but uniform. The States which have ground water organisations are Andhra Pradesh, Haryana, Gujarat, Madhya Pradesh, Maharashtra, Mysore, Orissa, Rajasthan, Tamil Nadu and Uttar Pradesh. Other States too are gradually building up their organisations. The manner in which programmes for ground water exploitation are organised and financed varies from State to State. For example, in Andhra Pradesh, the Agro-Industries Corporation functions on commercial lines in drilling and blasting in connection with ground water exploitation, though drilling is also the responsibility of the Departments of Irrigation and Public Health. Rajasthan has a State Ground Water Board fully equipped for drilling and blasting which also does geo-hydrological studies. The Board works under the Agricultural Production Commissioner. In Haryana, the ground water cell in the Irrigation Department is responsible for guiding all work connected with ground water assessment and exploitation, though actual drilling and installation of both State and private tubewells is done through a Corporation. In Mysore, drilling is the responsibility of the Department of Agriculture. while geo-hydrological studies are the responsibility of the Directorate of Mines. In Tamil Nadu, geo-hydrological work is carried out both by a cell in the Department of Irrigation and by the Agro-Industries Corporation.

12.47 The State of Haryana has constituted the 'Haryana State Minor Irrigation Tubewells Corporation' and Punjab, a similar Corporation 'Minor Irrigation Corporation' which are limited companies under the Companies Act of 1956. These organisations manage State tubewells and also carry out hydro-geological investigations for planning public tubewells. These Corporations have been established only a year ago. Their performance has yet to be evaluated.

12.48 We understand that the Union Ministry of Agriculture through a letter* has advised the State Governments to set up Ground Water Boards on the pattern of CGWB to do prospecting and development of both heavy duty tubewells and deal with the boring of shallow tubewells, wells etc. For reasons stated already, we regret we do not share the opinion of that Ministry.

12.49 In our opinion the State ground water organisation should have two divisions; one division with a predominantly engineering component should work under the State Irrigation Department. It should

*Ministry of Agriculture No. 18–31/70-T.W. of August 21, 1971.

be responsible for the exploration and assessment of ground waters, for studying the interaction of surface and ground water for their integrated development. It will also determine qualitative characteristic of ground water and for overall planning, research, design. construction, operation and maintenance of heavy duty State tubewells. The other division should be under the State Agriculture Department, and deal with the drilling and boring of private wells and tubewells, extension work, development of on-farm utilisation of water and the financing of private well and tubewell construction.

Control Boards for Large Projects

12.50 A large irrigation project involves many different activities and it is essential not only to co-ordinate the activities at the site but also those involving the departments of the State at headquarters. Such co-ordination is even more important in inter-State projects. To handle the many problems of co-ordination involved in construction, Control Boards have been set up in many projects.

We consider that all large inter-State projects and any State project costing Rs. 500 million or more should have a Control Board. Even for projects costing less than Rs. 500 million but which are of a complicated nature, a Control Board would be desirable. To be effective, Control Boards should be delegated the maximum powers and should in turn. be liberal in delegating powers to the Chief Engineers of projects in the interests of efficiency.

In States where several projects are under construction, a single Control Board with standing committees for each project would suffice. This would help to promote the best use of man-power and equipment.

Where a major project receives special financial assistance from the Union Government, the centre should be adequately represented on the Control Board.

Delay in the Execution of Projects

12.51 The major causes of delay in the execution of river valley projects are :

(1) Inadequate planning;
(2) delays in the acquisition of land;
(3) delay in the procurement of construction material particularly steel; and
(4) delay in importing construction equipment and spares.

Inadequate Planning

12.52 Faulty planning causes serious delays and increases the cost of a project. In most cases the fault can be traced to inadequate pre-construction planning.

We recommend that for all major projects a pre-construction planning cell should be set up. The cell should draw up a schedule covering all major items of work from sanction to completion. The schedule could be based on any one of the modern management techniques. It should cover, among other things, the preparation of initial drawings, the phasing of work and expenditure, the requirement of men, materials and the preparation of contract documents.

Land Acquisition

12.53 Recently, the Land Acquisition Review Committee set up by the Government of India to examine the provisions of the Land Acquisition Act of 1894 has recommended :

- (i) The setting up in each State of a Directorate of Land Acquisition under a Member of the State Revenue Board, which would be responsible for land acquisition;
- (ii) a regular monthly review of progress at the Collector's level;
- (iii) adequate pre-planning for the acquisition of land required by projects and the issue of notifications specifying the project areas. These notifications would be valid for two years within which period the land would have to be acquired;
- (iv) prescribing time limits for the Directorate of Land Acquisition to complete acquisition proceedings; and
- (v) special powers to deal with specific emergencies.

We endorse the recommendations made by the Land Acquisition Review Committee and trust that they will expedite the acquisition of land.

Delays in the procurement of construction material

12.54 Several major projects, such as the Beas Project in Punjab, the Ramganga and Gandak Projects in Uttar Pradesh, the Tawa Project in Madhya Pradesh, Ukai in Gujarat, Sharavati, Ghataprabha and Upper Krishna in Mysore, Kakrapar in Gujarat, Iddiki in Kerala and many others have been seriously delayed because of short supply of steel. These delays are often caused as the priorities allocated by the Government of India are not adhered to by producers.

The real solution of the problem lies in removing the shortages by increasing production and imports. With the improvement in the working of the existing steel plants and the setting up of new ones, we hope that steel shortages will be removed. Until this happens, we recommend that an assessment should be made of the requirements of steel for irrigation projects for the Fourth and the subsequent Plans and the Ministry of Steel & Mines should make every effort to meet the requirements of these projects.

Delay in the procurement of equipment and spares

12.55 The present value of construction equipment deployed on irrigation and multi-purpose projects has been estimated as about Rs. 1,050 million. Another Rs. 300 million worth of such equipment is with the private contractors working for these projects. To this amount is to be added Rs. 220 million as the value of spares. With the increased tempo of work on major river valley projects, another Rs. 200 to Rs. 300 million worth of equipment would have to be acquired in the next ten years or so.

12.56 The whole question of eliminating delays in the procurement of construction equipment and spares was examined by the 'Committee of Ministers' appointed by the Union Ministry of Irrigation & Power. Its main recommendations are : (i) modifications to import policy for procurement of critical spares and enhancement in value of foreign exchange for import of emergency spares, (ii) relaxation of some provisions of the import policy to quicken the processing of application for licences, (iii) setting up a central mechanical unit organisation in the States to guide proper utilisation and rehabilitation of surplus machines and spares, (iv) setting up a cell in the CW&PC to co-ordinate optimum utilisation, (v) identifying items for indigenous manufacture to substitute import, and (vi) quality control and pricing of indigenous parts.

We are of the opinion that when these recommendations are fully implemented the present difficulties would be substantially overcome.

Designs Organisations in States

12.57 We realise that even if possible, it is not desirable in the interests of economy, for each State to have a design organisation. States like Nagaland, Manipur, Meghalaya, Assam, Himachal Pradesh, and even bigger States like Andhra Pradesh, Bihar and Orissa seek the assistance of the CW&PC to prepare designs for them.

Other States like Uttar Pradesh, Punjab, Haryana, Tamil Nadu and

Maharashtra have set up their own central designs organisations supported by field units on each project. Mysore and Kerala have attached small design sections to each Chief Engineer.

In view of the importance which designs play in construction, we recommend that States should strengthen their design organisations. We generally favour, the concept of a central design organisation, to derive the full benefits of specialisation, pooling of experience and standardisation.

12.58 In Chapter XVII, the necessity for continuity of personnel in research organisations has been stressed by providing time-scales and built-in elasticity in grades with supernumerary promotion posts. This holds good for design personnel also.

Management of Irrigation Works

12.59 Efficient management and maintenance is efficient irrigation. This axiom is widely accepted. But there are variations in the extent of responsibility that the State Irrigation Departments are required to shoulder. In the States of the south, and in Maharashtra, the Irrigation Department is not responsible for the manner in which water is actually used in the field. Its responsibility ends at the outlet, and it is not concerned, either with the actual distribution of water among farmers or with its use by any individual farmer. In these States, the State Revenue Department is responsible, both for the distribution of water beyond the outlet, and for the assessment and collection of water dues.

In the northern States of Punjab, Haryana, Uttar Pradesh, Gujarat and Rajasthan, the Irrigation Department is responsible for the management of water from the source to the field. This includes the distribution of water among co-sharers on each outlet and the preparation of bills for the recovery of canal dues. But the recovery of these dues is the responsibility of the Revenue Department. In these States, the irrigation engineer is assisted by a canal revenue officer in regulating the supply of water to the field.

12.60 We are of the opinion that the system prevalent in the north has several advantages. It is necessary for the irrigation engineer to know how and where water is being used or misused. If we expect him to run the system efficiently, he must know the details of the end-use of the water which is being supplied. Only then can he be made responsible for achieving results and avoiding waste.

On these considerations, therefore, we would recommend that the southern States, and Maharashtra, might consider making the Irrigation

Department responsible for the management of water from the source to the field.

12.61 In Chapter XVI dealing with Irrigation Acts and Codes, we have dealt with legal provisions which might be adopted to deal with the menace of cutting canal and distributary banks. Here we would like to draw attention to the success which has been achieved in Haryana through extensive patrolling and inspection of canals and channels by flying-squads of officers, adequately armed. These flying-squads carry out surprise night inspections and whenever offenders are caught, heavy penalties are imposed on them. The essence of the system is surprise, and prompt and condign punishment. A similar system of inspection by flying-squads could be adopted with advantage elsewhere.

Set-up in State Secretariats

12.62 A brief description of the growth of Irrigation Departments in the States is necessary in order to understand their present constitution and procedure. When the Departments of Public Works were first constituted in the Provinces in 1849, they handled irrigation and also other public works like buildings and roads. The Secretariat and the Department of Works formed one unit. The Head of the Department also functioned as the Head of the Secretariat. In his capacity as Secretary, the Head of the Department had access to the Governor. Later on, a separate Irrigation Department was formed in some States, while in others irrigation continued to be a part of the responsibility of the Public Works Department.

So long as the Governor and senior officers of the Secretariat and the Department were British, the system worked smoothly. But, particularly after the First World War, when Indian engineers began to occupy higher posts including those of Chief Engineers, difficulties arose. Senior British officers, anxious to protect imperial interests, were reluctant to associate Indian officers with the formulation of high policies. Since the British element in the higher echelons of the Secretariat was preponderant, a decision was taken to create separate posts of Secretaries to Government, and to fill these posts by members of the Indian Civil Service, who were at that time almost all British. Separate posts of Chief Engineers were created to head departments outside the Secretariat. The Chief Engineers thus ceased to be Secretaries to Government. The first Province to enforce the new policy was Madras in 1925, followed by Bengal in 1927. Other Provinces followed suit later, with the exception of Assam. The bifurcation became an established practice even though the original basis for it had lost its relevance. Even Assam, which was the only Pro-

vince to make an exception, has lately appointed an officer as Irrigation Secretary who is not a Chief Engineer. In Gujarat and Maharashtra, Secretariats and departmental offices form a single unit and Chief Engineers are ex-officio Joint Secretaries to Government. We were informed that this system had streamlined the administration and had led to the expeditious disposal of work.

12.63 We have already mentioned the essence of the controversy as to the place of the generalist vis-a-vis the technocrat. Here we shall merely touch on the relationship of the Secretariat with the executive department of irrigation under the Chief Engineer. Traditionally, the functions of the Head of the Secretariat and those of the Head of the Department are distinct and separate. Their working relationship should, therefore, present no problem. Over the last two decades, however, in practice there has been a gradual deterioration in this relationship. Many Chief Engineers consider that they are not being given their due place in the hierarchy of the State Services and, therefore, feel frustrated. Views have been expressed that a closer integration between the functions of the two posts of Secretary to Government and Chief Engineer is necessary, and that unless this is ensured, the development programme may suffer. It has also been suggested that this closer integration can be achieved either by having an irrigation engineer as the Secretary to Government in the Irrigation Department, or by combining the posts of Chief Engineer Irrigation and Secretary Irrigation.

12.64 The Minister in-charge of the department decides policy, which is an amalgam of many factors—technical, administrative, financial, and political. He must get suitable advice on all these matters. It is not necessary that the same person should give him both technical and administrative advice. This leads us to the question whether the post of the Secretary and the Chief Engineer should be combined. After due consideration we are of the opinion that the present system of keeping the secretariat separate from the department is sound. In the succeeding paragraphs we propose to discuss how the Minister can get the best administrative and technical advice.

12.65 To expedite the clearance of technical proposals and to enable the Minister to have technical advice readily we recommend that a Chief Engineer should be appointed as an Additional or Joint Secretary in the State Irrigation Department. This, incidentally, would give the engineers a better sense of participation in the sphere of policy. The Additional or Joint Secretary would tender his advice to the Minister on technical matters and process such matters with other secretariat depart-

ments of the Government such as Finance, Planning and Agriculture. If for any reason there is difficulty in giving effect to this recommendation we suggest that one of the Chief Engineers should be given the ex-officio status of the Additional/Joint Secretary.

The latter recommendation is particularly relevant, though it may not conform to the principle of the separation of the functions of secretariat and department, for small states where the work load may not justify the appointment of a full-time Additional or Joint Secretary.

12.66 As we have said while discussing the question of the incumbency of the post of Secretary to the Union Ministry of Irrigation & Power, we see no reason why a technocrat, possessed of experience, vision and foresight, should be denied an equal opportunity of being appointed to the post of Secretary, Irrigation, in the States.

Administrative and Financial Powers to Departmental Officers

12.67 So far, we have been discussing the role of the Irrigation Secretary vis-a-vis the Chief Engineer, Irrigation. The present system under which a wide range of matters arising out of policy decisions are dealt with in the Secretariat imposes avoidable delays and creates bottlenecks which affect both cost and efficiency.

There is urgent need, therefore, to ensure that executive departments are delegated maximum powers to enable them to discharge their responsibilities with efficiency. Of late, we find that there has been some relaxation in the rules, and wider powers are now delegated by the State Governments to their Chief Engineers. However, in some States rules and procedures which were evolved a long time ago when the development of irrigation was limited, continue to be in force. We feel that the Chief Engineer, as the technical head of the department, should be vested, to the greatest possible extent, with the powers of Government in so far as these powers relate to the implementation of policy and connected matters. The advantages accruing from a wide delegation of powers cannot be overemphasised. Such delegation not only eliminates delays but gives field officers confidence. The massive programme of future irrigation development makes the delegation of powers all the more necessary. We are of the opinion that the Chief Engineer should, subject to the statutory powers of the State Public Service Commission, be delegated the maximum powers to appoint staff and full powers regarding transfers and postings of engineers up to and including Divisional Engineers. He should also have liberal powers to sanction expenditure within the limits of the funds appropriated.

12.69 By keeping the powers and functions of the Secretary separate from those of the Chief Engineer, and yet investing the latter with adequate powers to implement policy decisions, the principle of the separation of policy-making from implementation is preserved. The essential governmental function of scrutinising proposals and of shaping policy will be exercised through the Secretary, and his technical Additional or Joint Secretary, and policy will be implemented in the field by the Chief Engineer.

Matters relating to Engineering Service

12.70 The Union Government has already made provisions for the creation of an Indian Service of Engineers (ISE) by amending the All-India Services Act, 1951. It appears that some State have become lukewarm in regard to this matter and are reluctant to participate in the Service. We have not been able to ascertain the reason. However, for our part, we have little doubt that the ISE would attract the best talent available in the country and this would be of distinct advantage in improving both the morale and the working of the engineering services. We, therefore, recommend that early steps may be taken to set up the ISE.

12.71 During our tours, we were distressed to notice that large numbers of young engineers have been serving for too long in temporary posts. They do not enjoy the same security of service and pensionary and other benefits as members of the permanent cadre. It is no surprise, therefore, that there should be a sense of frustration among them. We gathered the impression that in some States the number of posts in the permanent cadre is inadequate, with the result that engineers have to be engaged on a temporary basis for long periods. We do not consider this to be a healthy practice and are of the opinion that temporary posts which have been in existence, and filled, for a period of five years or more should qualify for conversion into permanent posts. We recommend that the strength of permanent State cadres should be reviewed from time to time on this basis.

सत्यमेव जयते

PART III

WATERLOGGING, DRAINAGE AND FLOODS
SEDIMENTATION OF RESERVOIRS
INTER-STATE RIVER DISPUTES
IRRIGATION ACTS AND CODES
RESEARCH, EDUCATION AND TRAINING
IRRIGATION STATISTICS

सत्यमेव जयते

CHAPTER XIII

WATERLOGGING, DRAINAGE AND FLOODS

WATERLOGGING

An agricultural land is said to be waterlogged when the soil pores in the crop root zone get saturated with water. This is usually caused by a rise of the sub-soil water table. Waterlogging can also be caused by excess soil moisture due to periodic flooding, overflow by run-off, over-irrigation, seepage, artesian water and impeded sub-surface drainage. These conditions affect the growth and yield of crops. In course of time, such land turns saline or alkaline, and ultimately becomes unfit for cultivation. The valleys of the Tigris and the Euphrates, which were once very fertile, were rendered barren because of this malady. In India, in 1876 the 'Reh' Commission was appointed to find out why large tracts of land which had once been fertile, had deteriorated. The Commission traced the cause to the construction of big canals and the extensive use of irrigation water which had resulted in increasing the amount of soluble salts on the surface.

13.2 Large tracts in the Indo-Gangetic plain suffer from waterlogging. The erstwhile Punjab had the largest acreage. Signs of waterlogging also appeared in Maharashtra with the construction of the Deccan Canals. Even in recent projects, like the Chambal in Rajasthan and Madhya Pradesh, waterlogging has become a problem. As irrigation will be developed on a large scale in the next few decades, the necessary precautionary measures should be undertaken in advance.

Causes of Waterlogging

13.3 A continuous rise in the sub-soil water table takes place when a canal system begins to operate, particularly if irrigation from it is perennial. For example, after the opening of the Ganga Canal, the water table under the Ganga-Yamuna Doab rose from a depth of 12.2 m. to about 4.6 m. below ground level in 100 years. Similarly, in the areas

commanded by the Western Yamuna Canal, between 1932 and 1963 the water table rose at an average annual rate of 16 cm. The water level has risen even faster in some areas of the Punjab. Seepage from the canal systems, including water courses and field channels, is not the only factor which leads to a rise in the water table. Deep percolation from the irrigated area, often as a result of over-irrigation, also contributes to it.

13.4 Heavy percipitation and floods resulting in prolonged inundation also cause a rise in the water table.

13.5 Waterlogging depends also upon the nature of soils and sub-soils. For example, black cotton soil is prone to waterlogging because of its low permeability. Even when there is a permeable layer at the top, an impermeable stratum below can cause waterlogging because it prevents the downward movement of water. In the Deccan Canals tract, water percolating through a pervious layer of 'murrum'* often meets impervious 'chopan'** soils and is forced to the surface at the junction with the impervious strata. In the Bhogavo Irrigation Scheme in Gujarat, it was found that an impermeable rock barrier was blocking the sub-soil drainage and causing waterlogging over an area of 81 hectares. Even masonry structures, like causeways with foundations that go into the impermeable soil can obstruct sub-soil drainage and cause a rise in the water table.

13.6 The water table in nature is generally in a state of equilibrium with the inflow into the sub-soil balancing the outflow from it. But if the inflow increases due to the reasons mentioned above, and if there is no corresponding outflow through effective drainage or by pumping, there is a tendency for waterlogging to occur. Over most of the areas, in the Indo-Gangetic plain, irrigation is perennial and consequently the inflow into the sub-soil is considerable. The corresponding outflow is poor, due to the flat nature of the country and bad outfalls. Consequently, waterlogging here is more extensive than elsewhere.

Effects of Waterlogging

13.7 When the soil in the crop root zone becomes saturated, the plant roots are denied normal circulation of air; the level of oxygen declines and that of carbon-dioxide increases, as organic matter

Note :— *Murrum—Disintegrated trap or any other rock.
**Chopan—Stiff and impermeable soil varying in colour from light red to yellow.

decomposes with the saturation of the soil. The cutting off, or depletion, of the oxygen supply to plant roots results in wilting and ultimately in the death of the plants.

13.8 Well-drained soils warm up faster than saturated soils. The low soil temperature which results from excessive moisture in the soil not only hampers the germination of seed, but restricts development of the root system and affects the rate of ripening. When low soil temperatures are accompanied by poor aeration, the root system of plants does not develop properly and becomes vulnerable to attack by pests and diseases.

13.9 The soil structure is affected by water saturation and when tillage and cultivation of wet soil is resorted to, they tend to reduce normal biotic activity and root development. Cultivation becomes either impossible or difficult, in waterlogged soils. Natural flora such as weeds spring up and compete with crops.

13.10 The maximum damage is caused when the capillary water, coming to the surface, brings up in solution harmful salts from the soil or those present in the groundwater. In an arid region, the soils contain salts and when the water evaporates, these are left on the surface as deposits. A heavy concentration of salts renders the soil infertile.

13.11 A study of the effect of waterlogging on crop production was made at a small farm at Rauni near Patiala. This study showed that the yield per hectare for cotton which was about 746 kg. in 1951–52 dropped to 10 kg. in 1959–60 and the fields had become unfit for the cultivation of cotton. The drop in yield of wheat was from 1344 kg. per hectare in 1951–52 to about 896 kg. in 1958–59.

Extent of Waterlogging

13.12 Irrigation engineers have generally tended to classify as waterlogged, all areas where the depth of water table varies from 0 to 1.5 m. The States, in their replies to our Questionnaire, have listed the affected areas as follows:

Punjab: The State had the largest area affected by waterlogging which was estimated to be approximately 1.09 million hectares in 1958. Since then, a number of drainage schemes have been carried out, and waterlogging has been brought under control.

Haryana: According to an estimate made in October, 1966, 0.65 million hectares were affected by waterlogging, 0.62 million hectares

in the Western Yamuna Canal area and 31,000 hectares in the Bhakra Canal tract. The State has also reported that about 142,000 hectares under some branches of the Western Yamuna Canal have been affected by salinity and alkalinity, that soil surveys done before the introduction of irrigation in the Bhakra Canal area had indicated salinity or alkalinity over an area of 344,000 hectares, and that salts were usually met with at varying depths over the entire State.

Uttar Pradesh: No reliable records of the extent of waterlogging are available but it is estimated that about 0.81 million hectares are affected. The State also does not appear to have made any reliable assessment of land affected by salinity or alkalinity.

Bihar: Because of the flat nature of the country, large areas of north Bihar suffer from inundation due to floods in the various rivers. Even after the floods recede, water stagnates in a large number of depressions, known as 'chaurs'. The State has not furnished any precise figures for the area that suffers from waterlogging.

West Bengal: More than 2,590 sq. km. in Midnapur district are reported to be subject to waterlogging. In addition, another 1,295 sq. km. in districts like the 24-Parganas, Howrah and Hooghly are also reported to be affected.

Maharashtra: The total damaged area in the old Deccan Canals is reported to be 27,800 hectares, out of which 26,200 hectares have been damaged due to salts and the rest from waterlogging. The extent of waterlogging in other areas of Maharashtra has not been reported.

Rajasthan: Waterlogging has been reported in the Chambal command and the extent of it can be gauged from the fact that the water table which had been between 0 to 3 m. below ground had increased from 88,050 hectares in June, 1967 to 347,600 hectares in October, 1968. Even prior to irrigation, a soil survey indicated that 40,000 hectares had salts and alkalis in the soils. The effect of irrigation on the soils is yet to be assessed.

Madhya Pradesh: Waterlogging is being experienced in the Chambal command in much the same way as in Rajasthan. The extent of it can be gauged from the fact that 57,465 hectares had a sub-soil water table between 0 to 3 m. below ground level in October, 1968.

Mysore: It is reported that the extent of waterlogging under the Ghataprabha, Gokak, Tungabhadra and Bhadra Projects is 6,600 hectares, out of a total irrigated area of 0.43 million hectares.

Waterlogging is not a serious problem in the States of Assam, Orissa, Andhra Pradesh, Tamil Nadu, Kerala and Gujarat. Though replies have not been received from Jammu & Kashmir, Nagaland and Himachal Pradesh, it is not a serious problem in those States also, except for some areas in the Kashmir Valley.

Brief review of action taken so far

13.13 As early as 1925, the then Punjab Government constituted a waterlogging enquiry committee to study and report on the extent and causes of waterlogging which had assumed serious proportions in the irrigated areas and to indicate preventive measures. As a result of the enquiry, a small farm was set up at Chakanwali for field experiments connected with the reclamation of waterlogged areas and a laboratory was established at Lahore for the analysis of soils and water samples. This laboratory later came to be known as the Scientific Research Laboratory. Since Independence, the Land Reclamation, Irrigation & Power Research Institute at Amritsar has taken up this work. Some drainage schemes in the Punjab were executed with the assistance of the International Development Association (IDA) prior to 1964. The programme covered about 3,220 km. of drains, embankments and other allied flood protection works. Subsequently, seven pilot anti-waterlogging schemes were taken up covering the construction of surface and sub-surface drains, the installation of pumping stations, lining of canals, tubewells and seepage drains. The total area benefited by these schemes is about 160,000 hectares.

An extensive drainage programme has been undertaken in the last decade. Under this programme, a length of 4,480 km. of drains in Punjab has been completed so far. This has helped in improving drainage, and has checked the spread of waterlogging. A large number of shallow tubewells have been sunk by the farmers to provide water for their fields. This has also helped to check the rise in the groundwater table. Punjab is now able to state with confidence that it has brought waterlogging under control. It is understood that the water table is actually going down in certain areas.

13.14 The Bombay Public Works Department was the first to tackle the problem of waterlogging in the Deccan by forming a special irrigation research division in 1916. It carried out valuable investigations and Maharashtra State has implemented a number of drainage schemes, though many have yet to be taken up.

13.15 Other States have also been carrying out drainage works and such schemes as providing flood embankments to prevent the flooding of land, schemes to pump out drainage water and seepage drains adjacent to canals to prevent seepage. However, the Commission feels that a more vigorous and planned action on the lines of what has been done in Punjab, is called for in many other States. The Commission is particularly concerned about the possibility of serious waterlogging in the

ayacuts of the Gandak and Kosi Projects. The high water-table, heavy monsoon rainfall, perennial irrigation and the flat nature of the terrain are all conditions that make drainage difficult and cause waterlogging. The problem of waterlogging should be anticipated in these projects (Gandak and Kosi), and the Commission recommends that vigorous steps should be taken from now on, to prevent it.

In the context of waterlogging, mention may be made here of one or two interesting works visited during our tours.

In Haryana, the Jagadhri Tubewell Scheme which was designed to supplement the waters of the Western Yamuna Canal, pumps out water from areas which were waterlogged or had a high water table. Under the scheme, 256 tubewells were installed along the main line and main branch. Another 128 have been installed recently. Besides giving additional water to the Western Yamuna Canal, the scheme gave relief to areas which were affected by waterlogging or prone to it. Its example encouraged local farmers to sink their own tubewells taking advantage of the power lines that had been constructed for energising the State tubewells.

The Commission was also favourably impressed by the work being done under the United Nations Development Programme (UNDP) Project in the Chambal command in Rajasthan. One of the objectives of the Project is to find an answer to the problem of waterlogging. Experiments on lining channels and water courses are being carried out. Re-shaping and levelling of land, and the excavation of field channels and field drains are also being carried out on a pilot scale.

Remedial and Precautionary Measures

Drainage

13.16 The most effective answer to waterlogging is a properly designed drainage system. In fact, the menace of waterlogging would not have attained the present proportions if attention had been paid to drainage along with irrigation. The importance of drainage is so well recognised in advanced countries that it is always considered an integral part of any irrigation scheme. In East Germany, for example, no irrigation project is taken up without a corresponding drainage project. In this country, too, instructions have already been issued that irrigation project estimates should include the cost of drainage works.

Investigations of projects should include topographical, geological and soil surveys. The nature of soils and sub-soils from the point of view of permeability should also be studied. A knowledge of the water table and its fluctuations and the quality of groundwater in the area

proposed for irrigation is also essential. These studies should be of assistance in assessing the possibilities of waterlogging. Data regarding precipitation in the past, and its intensities, will have to be collected, and the drainage system suitably designed.

As a properly designed drainage system is essential for keeping an area free from waterlogging, the Commission recommends that the greatest attention should be paid to this item.

Field Drains

In areas waterlogged or prone to waterlogging, field drains to drain individual fields will be necessary. But as their construction and maintenance is to be done by farmers, the latter may need technical advice, with regard to such matters as alignment, depth and grade of drains. Drains must be deep enough to keep the groundwater at a level which would not be harmful to standing crops. In Maharashtra, excavation of drains to a permeable sub-stratum where it was available at a reasonable depth, has been successful. In the case of soils with low permeability, sub-surface drains, like tile drains, may be required. To design these properly, research and experiments will have to be conducted. The Commission recommends that, after research and experiments have been carried out, adequate technical assistance should be given to the farmers to enable them to build effective field drains.

Borrow Pits

Water generally stagnates in the borrow pits formed as a result of excavation for canals, and road and rail embankments. This is not desirable in an area prone to waterlogging. The Commission recommends that the indiscriminate excavation of borrow pits should not be allowed. If they are unavoidable, they should be so excavated that water will not stagnate but flow into the nearest drainage system.

Use of Ground Water for Irrigation

13.17 We have already discussed the merits of the conjunctive use of surface and ground waters. Adequate provision for such use should be made in the planning of new projects, because it helps to keep waterlogging under control. Farmers should also be encouraged to dig wells and sink shallow tubewells. We have been informed that the construction of a large number of shallow tubewells by farmers in Punjab has helped to keep the water table down. The Commission recommends that necessary technical and financial assistance should be given to the farmers for the construction of wells and shallow tubewells.

Lining of Canals etc.

13.18 It has been pointed out in Chapter VI that lining is of great importance in areas which, on the introduction of irrigation, are liable to waterlogging and salinity and that if lining is done at the initial stage, it will cost much less than if done later. This point should be kept in mind when considering irrigation projects in the areas susceptible to waterlogging.

Crop Pattern

13.19 In areas susceptible to waterlogging, it will be desirable to introduce only those crops which need light irrigation. Crops requiring heavy irrigation will have to be controlled. In the Deccan Canals of Maharashtra, when the irrigation of sugarcane was allowed, it was found that large areas were affected by waterlogging. Restrictions were thereupon imposed on the irrigation of sugarcane as described earlier in Chapter VI. This system of restricting the area under sugarcane contributed substantially to the prevention of large-scale damage through waterlogging. The Commission recommends that similar crop restrictions should be enforced in other areas prone to waterlogging. Soil survey data should be made use of, in fixing crop patterns and intensities. In schemes where crops are localised, the Commission recommends that crops needing heavy irrigation, should invariably be restricted to the valleys.

Water Management

13.20 Land shaping is necessary to prevent the accumulation of water in the fields. Sound water management methods should be demonstrated and introduced right from the time that irrigation commences. This will not only lead to economy in the use of water but will avoid the danger of waterlogging.

Post Irrigation Observations

13.21 The behaviour of ground water levels after the introduction of irrigation has to be studied. The depth of the sub-soil water table has to be observed in selected open wells distributed over the ayacut, with a greater concentration in low lying areas. The observations are generally made twice a year, once in June before the monsoon, and a second time in October after the monsoon. This, no doubt, gives the relative water levels in those months, but our objective is to know the variations in the

water levels from year to year. It is the difference between the two water levels in the month of June in two consecutive years which will give an idea of the yearly variations. The quality of ground water should not be overlooked. The Commission recommends that an annual review should be made of these observations. A continuous rise in the water table should be viewed seriously and investigated, and suitable remedial measures taken.

DRAINAGE

Importance of the problem

13.22 Surplus water is as harmful to crops as inadequate water. The drainage of superflous water from irrigated land is, therefore, as necessary for the satisfactory growth of crops as irrigation. There are places where irrigation may not be required during the monsoon season though drainage is necessary. The rainfall in parts of West Bengal. for instance, is sufficiently heavy to permit a rice crop to be raised successfully without any irrigation. But without proper drainage, the crop cannot thrive. If the monsoon starts early, there are areas where kharif crops cannot even be planted because of the standing water. Similarly, there are areas where rabi crops cannot be sown in time because of excessive moisture in the field.

13.23 It is not only the accumulated surface water from heavy precipitation or flood water that needs draining, but also the excess water in the field due to over-irrigation or seepage from an adjacent channel that has to be removed to help crop growth. It is interesting to note that in certain poorly drained areas, in years of poor rainfall the farmer gets a better than usual crop. In general, in a well-drained soil, production is likely to be above average. We are informed that after the drains in the West Godavari Delta were improved under the Intensive Agricultural District Programme (IADP) there has been an appreciable increase in yield.

Drainage System

13.24 To remove excess water from the surface or sub-soil a drainage system is necessary. The drainage system of an area is the reverse of the irrigation system. Just as the main canal takes off from the river, branches off into distributaries and minors and finally ends in field channels supplying water to individual fields, in reverse order, the drainage is collected from the individual fields through small field drains.

They fall into a minor drain which in turn may join a major drain and ultimately empty into a river or the sea. Field drains are generally maintained by the farmers, but minor and major drains which form the middle links in a drainage system should receive systematic attention from the State. Very often drains are the natural water courses or the 'nullahs' or are formed out of them and inherit all their ills, such as zigzag courses and inadequate sections and banks.

Areas of Drainage Congestion

13.25 Where the country has a flat slope as in the Indo-Gangetic plain, the Brahmaputra and the Barak valleys, parts of Gujarat and in the deltaic areas of the rivers like the Ganga, the Mahanadi, the Godavari, the Krishna and the Cauvery, the drainage problem is naturally acute. In the case of deltas there may be some tracts whose levels are just a few feet above sea level. The drains in such tracts are generally affected by tides from the sea and the drainage flow is held up for a part of the day.

Special Problems with Drains

13.26 Drains suffer from the inherent difficulties, mentioned below:

(1) Unlike irrigation channels, drains carry a variable flow. When there are heavy rains they get flooded; but normally they carry small flows. As a result, they are susceptible to erosion and silting up and do not maintain their sections for long.

(2) Because drains run with low velocities for most of the time they suffer from weed growth. Weeds choke the waterway and there can be no worse enemy than the water hyacinth for destroying the functioning of these drains. Plants growing on the berms and the banks of drains can also affect their functioning.

(3) The repair and maintenance of drains is also difficult because they are often located far away from roads and other means of communication. Work may have to be carried out under water, and in the case of deep drains and drains subject to tidal action, equipment such as dredgers is needed.

(4) Normally, drains do not receive as much attention from inspecting officers as canals, since they are situated away from irrigation canals and channels. They rarely carry inspection banks. Complaints about drainage come from only a section of farmers and only at certain periods. All these result in a lack of attention to drains.

(5) Roads, railroads and canals cause obstruction to drainage in many places, because their structures are designed with an eye to economy, with the result they cause an afflux in water levels and create congestion.

At road crossings most often only causeways are provided, which cause considerable afflux at times of floods, just when it is essential for drains to function efficiently.

(6) Cross bunds are often put up across drains, sometimes with the permission of the authorities and sometimes without, to divert or pump out water for irrigation or to facilitate nevigation or fishing. Generally, these bunds are not entirely removed after they have served their purpose. As a result, the drains deteriorate, and their normal functioning is affected.

Suggestions for Drainage Relief

New Projects

13.27 We have mentioned in Chapter V the need to include the cost of drainage works in the estimates of new irrigation projects. We would like to reiterate that this should invariably be done, and adequate provision for drainage made in all new works.

Existing Works

13.28 Many irrigated areas have some sort of drainage system. But in some areas where drainage is most needed, it is not adequate. The existing drains have often been neglected for so long that detailed investigations and designs are needed to restore their functioning. The Commission is glad to observe that the States are aware of the importance of drainage and have started taking steps to improve it in their irrigated areas. Their plans include the excavation of new drains as well as the remodelling of existing ones. The Government of Uttar Pradesh, in its recently completed Master Plan has proposed to increase the waterways in 182 masonry works which had been obstructing drainage. New drains and remodelled drains will run over a length of about 6,100 km.

In the Kashmir Valley, the interesting and recently completed Sonawari Reclamation Scheme collects the drainage from low lying areas, pumps it out and uses it for irrigation. The area covered by the scheme is 20,000 hectares.

West Bengal has drainage difficulties over about 0.4 million hectares. New drains, remodelling of existing drains and pumping schemes are being taken up. Works completed and under progress will provide relief to about 101,200 hectares.

Andhra Pradesh, besides experiencing the usual drainage difficulties in its deltaic areas, has a major drainage problem at the junction of the

Godavari and Krishna Deltas. Here, drains both from inside and outside the deltas fall into a natural depression known as the Kolleru Lake, and the outfall from the lake is through a drain known as Upputeru, which falls into the sea after flowing for a length of 63 km. Whereas the Kolleru receives a peak flow of 2,830 cumecs, the Upputeru is capable of discharging only 320 cumecs, when the water of the Kolleru is 3 m. above mean sea level. At this level, the resulting submersion is spread over nearly 40,500 hectares. Every 30.5 cm. of rise in the water level at this stage causes an additional submersion over an area of nearly 7,700 hectares. The Government of Andhra Pradesh is already taking steps to give relief to this area according to the recommendations of an expert committee which submitted its report in December, 1965. The major recommendations include proposals for the construction of detention reservoirs across the big streams flowing into the Kolleru from outside the delta, and improving the capacity of the Upputeru including the formation of flood embankments and a straight cut to the sea from an appropriate point.

13.29 The Commission hopes that the States will continue the steps taken by them to improve the drainage system in their irrigated areas. Besides excavating drains to adequate sections, bad curves in them could be eased and other works carried out to improve land drainage. We would like to draw pointed attention to the need for examining the waterways at bridges on roads and railway embankments, and cross drainage structures across the canals in order to make them adequate for the purpose of preventing undue afflux. Particular attention should be paid to the improvement of the waterways in the causeways across drains, so that they cause the minimum obstruction to drainage. We would also suggest the provision of inner deep sections in drains wherever possible, to carry the normal flow. Such sections help in maintaining proper velocities for keeping down silting and weed growth.

Inspection of Drains

13.30 Frequent inspections by departmental officials are essential to ensure that drains are not meddled with unauthorisedly and their functioning obstructed. When obstructions are permitted, it should be ensured that these are completely removed before the monsoon. Also, regular inspections will be needed to see that drains are properly maintained. They should be inspected soon after the rains are over so that sufficient time is left for carrying out any repairs that may have become necessary. Masonry profiles put up at intervals will make it easy to detect if the drains are maintaining their designed section.

13.31 The Commission recommends that facilities for the inspection of these drains should always be provided. Service roads should be laid along major drains wherever possible; otherwise, inspection paths at least may be provided. In the case of drains that may be navigable for most of the time, some floating craft could be maintained to facilitate inspections. The hands of the departmental officials should be strengthened by suitable laws, where they do not exist now, so that unauthorised meddling with the drains could be curbed without delay.

Maintenance of Drains

13.32 Drains deteriorate rapidly due to the various causes mentioned earlier. If not attended to regularly they can soon become ineffective. Weed growth is the most common trouble and requires periodical clearance. Silt accretion at bends and at masonry works, such as cross drainage structures across canals and road causeways, is another problem. The Commission recommends that weeds and silt at critical places should be removed before every monsoon season. The minimum funds for this operation will have to be provided. We further recommend that irrigation officers should, before the commencement of the monsoon season, issue a certificate that the drains have been cleared of weed growth and silt, and are in good condition.

Funds for Maintenance

13.33 In some States, funds for the maintenance of both irrigation and drainage works are clubbed and a lumpsum provision made, with a result that there is the possibility of drainage works not getting their due share for maintenance. We recommend that funds for the maintenance of drains be allotted separately, so that drains are not neglected.

From the replies received from the States, it appears that their main problem in maintaining drains is want of adequate funds. However, the example of Andhra Pradesh shows that the problem can be overcome. The State proposes to collect a drainage cess under the 'Andhra Pradesh Krishna and Godavari (Delta area) Drainage Cess Act (1968)'. The Act provides for the levy and collection of a drainage cess for a period of six years, on all land lying within the delta area of the Krishna and Godavari rivers to pay for the drainage schemes undertaken in the area. The Northern India Canal and Drainage Act, 1873, provides for the recovery of a portion of the cost incurred by way of an annual rate, from the beneficiaries. The Commission recommends that the States should carefully examine whether any levy could be imposed on areas which have benefited from drainage works. If such a levy can be imposed, necessary measures for the recovery of the levy should be taken.

FLOODS

Importance of the Problem

13.34 Although the Commission has not been specifically asked to examine the problem of floods, we are concerned with it because irrigation cannot be introduced in certain areas unless they have been rendered free from floods. We are also concerned about the damage caused every year by floods to numerous irrigation works and irrigated areas. The extension of irrigation in the Purnea and Saharsa districts of north Bihar, previously subject to floods in the Kosi, would not have been feasible but for the flood control works carried out on the Kosi river. The sudden floods in the Ganga in 1970 led to heavy silting up of the Upper Ganga Canal from its head for a distance of about 11 km. The canal was closed as a result, for nearly nine weeks, at a time when water for late kharif crops was most needed.

We would, however, like to emphasise that complete protection from floods can seldom be achieved even if it were to be technically feasible. It may not be economically justifiable to carry out works for cent per cent protection from floods. Most of our flood control works aim at minimising the damage caused by floods and protecting as large an area as possible against floods as is economically justifiable. Apart from carrying out flood control works, steps should also be taken for flood forecasting and warning so that timely steps may be taken to reduce the loss of life and property from floods.

Areas affected by Floods

13.35 Floods have been damaging large irrigated areas in the Indo-Gangetic plain, particularly in north Bihar, eastern Uttar Pradesh, Punjab, Haryana, portions of Rajasthan and also the coastal areas in Orissa, Andhra Pradesh and Tamil Nadu. The damage is acute in the delta areas of the Mahanadi, Godavari, Krishna and Cauvery rivers. Floods have also caused damage to the areas irrigated by tanks in Peninsular India, particularly where these tanks are in series and the breaching of one tank leads to the failure of tanks below.

Integrated Planning for Flood Control and other benefits

13.36 The best way to control floods is to intercept them with storage reservoirs, so that only moderated floods are allowed to flow through the valley below. However, reservoirs constructed merely to detain and moderate floods may not be economically justifiable. On the other

hand those constructed for irrigation, power, etc., could be planned to provide for flood control also. The works carried out by the Damodar Valley Corporation in the Damodar river basin and the various benefits conferred by them, are the result of such planning where the primary aim was flood control. The rains experienced all over the Damodar Valley in the middle of September, 1958, led to a high flood in the Damodar and its tributaries. Had there been no reservoirs, the maximum flow at Durgapur would have been of the order of 18,800 cumecs and would have caused considerable damage in the valley. But the flood was absorbed by the reservoirs and their careful operation helped to avert a catastrophe.

13.37 The Hirakud Reservoir is another multi-purpose project that was primarily needed for flood control. The reservoir is not filled to capacity till the middle of August, so that it can absorb whatever floods may come in. Water is released, taking into account the inflow into the river below the reservoir. Thus, floods in the Mahanadi delta are kept under reasonable control.

13.38 The above examples illustrate the great advantage of incorporating the flood control aspect in the planning and designing of multipurpose dams, singly or as a part of a basin plan. We recommend, therefore, that in planning and designing future river valley projects, the flood control aspect should be prominently kept in view.

Construction of Embankments

13.39 Storage reservoirs in the upper reaches of a river do not always succeed in checking floods. This is because even the moderated flows that they release into the river may exceed its carrying capacity. Besides, they cannot check the run-off from the catchment below the reservoir. In the circumstances, it becomes necessary to construct embankments in order to protect large areas on either side of the lower reaches of a river.

13.40 Embankments are not unmixed blessings. They obstruct free drainage of the land outside the embankments into the river. The valley storage is reduced and consequently the flood levels in the embanked reaches rise. In turn, the flood levels in the upper reaches also rise and this leads to demands for the extension of the embankments. Floods of higher stage and consequently higher damage potential are transferred to unprotected areas downstream. Embankments are also liable to failure and when they fail, the damage can be much greater than if

there were no embankments. Another argument against embankments is that in many cases they prevent the deposition of fertilizing silt on lands subject to flood inundation.

13.41 Because of these disadvantages, the suitability of embankments has been a matter of controversy and opinions have differed from State to State and have suffered many changes. In certain cases their construction has been prohibited by law. A case in point is the Bengal Embankment Act, 1873. It is only in the last two decades that opinion has veered round in favour of embankments and they are now being constructed on a large scale.

13.42 We would, therefore, like to emphasise that in providing embankments on a river to prevent the inundation of adjoining areas, the attendant problems should be carefully considered and suitable designs evolved to minimise ill-effects. The most important precaution to be taken is to provide suitable drainage for the land behind the embankments. The drainage should be led through sluices in the embankments or into the river below the embanked reach.

Maintenance of Embankments

13.43 Though the need for carefully watching and maintaining flood embankments is recognised, we would like to lay special emphasis on this aspect, since neglected embankments are liable to be breached and can cause great havoc. To facilitate maintenance at the appropriate time, longitudinal sections and cross-section of embankments should be taken at regular intervals and the embankments brought to proper standards. The river regime should also be studied by taking cross and longitudinal sections of the river. The points of attack by the river should be listed and carefully watched and action taken in time to protect vulnerable reaches. We would recommend that an annual systematic post-monsoon check of all important embankments should be made and necessary repairs undertaken. Before each rainy season an inspection of the embankments should be made and the inspecting officer should sign a certificate in token of having done so, pointing out at the same time any weak spots requiring special watch during the season.

Other Flood Control Measures

13.44 Sometimes it may be possible to divert a portion of the flood from a river into an adjacent valley or away from an area where it causes

damage. The Budameru in Andhra Pradesh is an example. The flood in this stream was aggravating the problems of the Kolleru lake. Now 210 cumecs of its flow are diverted into the adjacent Krishna river. In Rajasthan, the Ghaggar has been flooding large irrigated areas (54,600 hectares in 1964) of the Bhakra, Bikaner and Rajasthan Canal commands. To prevent this, a flood control scheme has been executed at a cost of about Rs. 40 million. Under this scheme, a diversion channel—51 km. long with a designed discharge of 340 cumecs has been excavated to divert the flood waters to a number of depressions in sand dunes south of the irrigated belt.

13.45 The flood-carrying capacity of a river channel could be improved by deepening and widening it and by removing bad curves. Action on these lines is being taken on the Jhelum in the Kashmir Valley.

Flood Forecasting

13.46 Flood damage could be avoided to a considerable extent if timely warning could be given of an impending flood. "Forewarned is forearmed". Flood Forecasting is all the more important for the operation of multipurpose reservoirs. With a good working system, floods can be considerably moderated and water can be conserved. Regulators in canal systems can be operated in time, if a flood warning is received sufficiently in advance.

13.47 Forecast of floods can be made with the aid of prompt information regarding the river stage in the upper reaches and the amount of rainfall received. The Central Water & Power Commission has been forecasting the floods in the Yamuna at Delhi from 1958. It gets the river stage from Kalanaur about 200 km. upstream of Delhi and is able to forecast floods about 48 hours in advance. In 1969, it established a Central Flood Forecasting Directorate and started by forecasting floods at:

(1) Gauhati on the Brahmaputra.
(2) Jalpaiguri on the Teesta.
(3) Varanasi, Buxar, Patna, Hathidah and Azambad—all on the Ganga.
(4) Delhi on the Yamuna.
(5) The Sahibi (for Rajasthan).
(6) Broach on the Narmada.
(7) Surat on the Tapi.
(8) Rajghat on the Subernarekha.

Since then, it has added many more stations and rivers to the list. It is

also planning to improve methods of forecasting by the electronic analogue technique, mathematical models, etc. Wireless is coming more and more into use for the collection of data. We recommend these steps and hope that in due course it would be possible to establish a satisfactory flood forecasting service at all places vulnerable to floods.

Flood Patrolling

13.48 Flood patrol rules have been prepared in several states and according to these rules, a suitable machinery is set in motion when flood warnings are received. Night and day patrolling of vulnerable points is arranged. Flood stores are maintained at convenient places so that materials required for meeting emergencies such as breaches of embankments are readily available. We suggest that patrol rules should be prepared and made available for guidance at all places vulnerable to floods. These should include instructions for the maintenance and checking of flood stores and the manner of dealing with emergencies. Sufficient copies of these rules should be printed so that they are readily available to all who have to deal with floods.

General

13.49 With the construction of big reservoirs in the coming decades, we are hopeful that flood damage will be minimised in many parts of the country. The Brahmaputra Flood Control Board and the Brahmaputra Flood Control Commission have already been formed to tackle the flood problems of the area. Similar bodies are being formed to deal with floods in the north Bengal rivers. Recently, the Government of India announced its intention to set up an autonomous board and a commission to tackle floods in the Ganga Basin. With the above bodies concentrating on flood control work, the Commission hopes that the damage caused by floods in these areas will be reduced in due course.

13.50 The systematic collection of hydrological data is important for forecasting floods and designing flood protection measures. We have already stressed the importance of this work in Chapter III as part of the process for Water Resources Development. We would like to reiterate this in the context of rendering our irrigated areas free from floods.

CHAPTER XIV

SEDIMENTATION OF RESERVOIRS

The Problem of Sedimentation

The effective life of a storage reservoir depends on the rate at which silt is deposited by the rivers flowing into it. Dead storage to hold the deposited sediment is specifically provided in the design of dams and reservoirs. The dead storage capacity is based on the assumption that the sedimentation rate varies from about 14,287 cu.m. to 71,435 cu.m. per annum for every hundred sq.km. (30 to 150 acre feet per annum for every hundred sq. miles) of catchment area. Where the data needed to calculate the rate of deposition is not available, Dr. A.N. Khosla's formula, which assumes that 35,718 cu.m. of sediment is deposited for every hundred sq. km. of catchment (75 acre feet per every hundred sq. miles) is applied. Normally the economic life-span of a project is assumed to be a hundred years and the dead storage capacity is provided accordingly.

14.2 In recent years, studies have been made of selected reservoirs, to assess the sediment load carried by rivers, and the rate at which silt is being deposited. Data relating to 22 reservoirs has been compiled by the Soil Conservation Directorate of the Central Water & Power Commission (CW&PC). The Table 14.1 gives details of the findings relating to eight of them. In the Tungabhadra reservoir, the table shows that against the assumed siltation rate of 42,861 cu.m. per hundred sq. km. (90 acre feet per hundred sq. miles) of catchment, the observed rate is 181,927 cu.m. per annum for every hundred sq. km. (382 acre feet per annum for every hundred sq. miles). At this rate the dead storage of the reservoir will be filled in 22 years, and the live storage in 74 years. In all the reservoirs mentioned in the Table 14.1, the observed rate of siltation is much higher than the rate initially assumed.

14.3 The figures highlight the unreliability of the data on which the dead storage capacity of the reservoirs was calculated, and the need for more accurate assessments in future.

Table 14.1
Siltation in Selected Reservoirs

S. No.	Reservoir	Annual rate of siltation in acre ft.		Assumed silt index	Observed silt index
		Assumed	Observed	(In acre ft. per 100 sq. miles of catchment area)	
1	2	3	4	5	
1.	Bhakra	23,000	33,745	105	154
2.	Maithon (DVC)	684	5,980	28	300
3.	Panchet (DVC)	1,982	9,533	47	251
4.	Ramganga	1,089	4,366	90	377 (Silt charge in the river)
5.	Tungabhadra	9,796	41,058	90	382
6.	Mayurakshi	538	2,000	75	284
7.	Nizamsagar	530	8,725	6.33	104
8.	Ukai	7,448	21,758	31.	105.3

14.4 We observed the effects of accelerated sedimentation at Nizamsagar. The reservoir has already lost a substantial portion of its storage capacity because of silting, a mere thirty years after its construction (1931). When the Andhra Pradesh Engineering Research Laboratories, Hyderabad, conducted sedimentation studies of the reservoir in 1967, they found that its capacity had been reduced from 843 m.cu.m. to 403 m.cu.m. that is to say, by about 52.1 per cent. The loss in dead storage capacity was as high as 97.11 per cent while in live storage it was 44.87 per cent. At the present rate of sedimentation, the reservoir is not likely to last for more than a few decades. The magnitude of the loss can be gauged from the fact that the reservoir was expected to last one hundred years. Among the measures suggested to mitigate the effects of the rapid silting up of the live storage are the increase in the Full Reservoir Level (F.R.L.) which can be achieved either by raising the height of the shutters or by fixing them on a raised weir wall, and the construction of a new reservoir higher up at Devanur, in Mysore State. The first measure will, to some extent, make up for capacity lost through sedimentation, while the second will reduce the silt flow into the reservoir. However, these measures, at best, are merely palliatives and both Nizamsagar and the suggested reservoir at Devanur are bound to get prematurely silted up. unless the heavy sediment flow from the catchment is effectively checked through water-shed protection aimed at conserving the soil in situ.

Factors contributing to Sediment Production

14.6 The rate at which silt is brought down from the catchment of a river basin depends upon the nature of its soil and various other characteristics. The upper catchment of a basin in hilly or mountainous terrain is particularly subject to erosion. While erosion is nominal in forest land, it is aggravated by the uncontrolled felling of trees, burning of vegetation and grass, and encroachment, for agricultural and other uses on forest land.

14.7 The steeper the slope and the less unconsolidated the rock formations, as in the Himalayas, the greater the erosion. In such areas, huge volumes of silt are precipitated into the streams and rivers through slips and land-slides caused by rain or snow. These sometimes cause temporary obstructions to the flow of water, and serious floods occur when the obstructions are swept away under the pressure of the water. The construction of roads in such areas had led to severe road side erosion, the drift of detritus and silt, and an increasing silt load in the streams.

14.8 Other factors contributing to the sediment load are the nature of the soil, a high intensity of rainfall, deforestation, earthquakes, mining operations, over-grazing, poor drainage and the cultivation of the foreshores of reservoirs.

14.9 Finally, there is the erosion in agricultural land from which silt is carried away by the run-off of rainfall. Studies have revealed that nearly 50 per cent of the catchment of river valley projects consists of agricultural land. Here, unless due and timely precautions are taken to prevent it, erosion leads to the formation of gullies and ravines which become sources of fine silt.

Location of Sediment Deposit

14.10 Some of the sediment in a river may be deposited upstream of a dam, some may pass through it without being deposited, much of it is deposited in the 'dead' storage, but some of it may also find its way into that portion of the dam which is reserved for live storage. The problem of encroachments on the live storage capacity is more acute in reservoirs like Hirakud, where the water-spread area behind the dam is very large and silt is deposited in the shallows on the edge of the lake.

The situation calls for continuous survey and study, not only of the

rate of sedimentation, but of the location of sediment deposits. Both these factors are relevant in calculating the effective life of a reservoir. We recommend that surveys should be carried out at three-year intervals. to assess the rate of sedimentation and the location of sediment deposits in all reservoirs in the country.

Sedimentation data relating to reservoirs should be annually compiled and published. In addition, the CW&PC should bring out a comprehensive review, once in six years with detailed statistics so that a clear exposition of the sediment position in reservoirs is available to the public.

Measures for Control of Sedimentation

14.11 An efficiently designed reservoir which provides for the discharge of sediment through properly located outlet works, either by sluicing or by density currents. has a built-in capacity to control the sedimentation process.

14.12 Other methods which serve a similar purpose are excavation and dredging of the reservoir, flushing, flood-sluicing or controlled water-sluicing, and sluicing with hydraulic and mechanical agitation. However, except in the case of small reservoirs, where short interruptions of their functioning can be tolerated, or in reservoirs which are mainly constructed for flood-control and provided with large outlets at the base of the dam, these methods are neither economical nor technically feasible.

14.13 Soil conservation is the usual method of protecting the water shed and is achieved through such measures as afforestation, pasture development, protection of river fringes, road sides and the shore-line of reservoirs, and the control of forest fires which ravage tree and grass growth.

14.14 For an effective soil conservation programme it is necessary first to locate the rivers and streams which carry a higher than normal silt load. The next step is to locate the sources of sediment in the catchments of these streams and rivers, and to assess the amount of sediment carried. This entails a systematic observation of silt loads and discharges at selected observation stations.

14.15 We are happy to note that a beginning has been made in this direction with the establishment of 235 silt observation stations during the Third Plan. We recommend that the network of such stations should be extended without delay to all important projects. Wherever stations

do not exist, a rough estimate of sediment yield should be formed, based on erosion data collected by research stations with comparable hydrological conditions and land-use patterns. The sediment sources can also be located by aerial photography, to determine priorities in the programme of soil conservation.

14.16 As much as 304,000 sq. km. of the catchments of twelve centrally sponsored river valley projects have been covered by aerial photography carried out by the Survey of India, up to the end of the Third Plan period. We recommend that the rpogramme should be extended to the remaining centrally sponsored projects.

14.17 In this connection, we draw attention to the practice in the United States of America (U.S.A.), where areas are surveyed and classified according to their sediment-producing potential. The identification of the source and character of sediment, enables the soil conservation authorities to pin-point vulnerable areas in the catchment, and to treat them. In the U.S.A., sources of sediment in the catchments of all authorised projects are treated either prior to, or simultaneously with the construction of the dams.

14.18 An effective soil conservation programme must be based on a classification of land capability. For this purpose, soils have to be surveyed and classified according to their capacity to sustain various cropping intensities and to resist erosion. On the basis of this classification. the areas which require treatment have to be listed. The treatment could consist of afforestation, or pasture development, or a combination of these and other measures to conserve and protect the soil, so that it assists percolation and seepage and the absorption and storage of water. A protected catchment prevents rapid run-off and moderates floods. It is generally accepted that land with more than 10 per cent slope should be earmarked for forests or pastures, based on its capability, and land with less than 10 per cent slope, should be used for agriculture. This is not to say that the beneficial effects of afforestation are not experienced on slopes below 10 per cent or on level land. The growing of forested shelter belts in cultivated areas in Russia, for example, is said to have increased production by 10 to 15 per cent.

14.19 Although improved land management, and protection of the vegetative cover are keys to the control of sediment, there may still be need for engineering structures such as revetments, check dams, debris basins, stream-bank stabilisation. However, the effectiveness of these measures is reduced, or even nullified, if simultaneous action is not taken to control deforestation, overgrazing, burning and harmful

agricultural practices. which destroy vegetation. In the absence of vegetative cover on land in the catchment, any engineering works erected to control erosion might be quickly destroyed in the floods which characterise an unprotected catchment. During our tours we noted with regret that almost everywhere soil conservation programmes on agricultural land are confined to bunding. Little or no attention appears to have been paid to other soil conservation works. such as contour cultivation, strip cropping.

We would recommend that follow-up measures should invariably be taken, so that farmers get the full benefits of soil conservation.

Special Problems

14.20 A major soil conservation problem is caused by the wasteful and destructive practice of shifting cultivation (Podu or Jhum). Large areas of hill slopes in Assam, Nagaland, Bihar, Madhya Pradesh, Orissa, Andhra Pradesh, Maharashtra, Himachal Pradesh, Manipur, Tripura, Goa and Arunachal suffer from this practice and the hills are being denuded fast, not only of their forest cover but of their top soil. The absence of terracing or bunding, and reduction in the rotational period of shifting cultivation, leads to the washing away of rich soil which adds to the sediment load of streams and rivers.

14.21 The best way to reclaim these lands would be to put them once again under forests. However, there are practical difficulties in doing this, not the least being that the vast majority of those who practice shifting cultivation are tribals. The problem, therefore, has sociological implications and stringent measures would be out of place. Wherever land in the plains can be given to these tribals it should be done, although they would have to be taught methods of cultivation appopriate to the new areas. If it is not possible, to give them land elsewhere it will be necessary to establish demonstration farms to teach the tribals improved methods of cultivation, and the art of bunding and terracing, so that they can gradually give up their present practices, which lead to the impoverishment of the soil.

14.22 In the portion of the Machkund catchment lying in Andhra Pradesh. a demonstration scheme of this kind was taken up in 1963–65, in ten villages. Free seeds, fertilizers etc. were given to the tribals who were also assisted in implementing soil conservation measures. It is reported that in one area alone. there was an overall increase in farm production valued at Rs. 32.037 (Rs. 276 per family) with the result that the tribals gave up the practice of shifting cultivation and took to

settled agriculture. We recommend, therefore, that wherever shifting cultivation is practised in the catchment area of a river valley project, steps should be taken to educate the tribals in improved methods of cultivation, and on the advantages of terracing. Technical help and financial assistance to them should also be given.

14.23 Over-grazing of pastures, and encroachment by cattle into forested areas for grazing, are also factors which assist the destructive erosional process. All such grazing is incompatible with scientific forestry, and leads to the destruction of the vegetative cover. The maximum damage is caused by goats, but sheep and cattle are hardly less destructive.

14.24 The National Forest Policy recommends rotational grazing, and the levy of reasonable grazing fees to prevent indiscriminate grazing. We entirely agree with these recommendations, particularly with regard to the catchments of river valley projects.

14.25 We are happy to note that many States such as Haryana, Kerala, Maharashtra, Orissa, Tamil Nadu, Punjab, West Bengal and the Union Territory of Delhi, are taking steps to deal with this problem. We were also glad to observe that the Forest Department of Rajasthan has commenced enclosing pastures which have been degraded by over-grazing, in order to protect the Chambal catchment area. As a result of this measure there has been a good growth of grass in the enclosed area.

14.26 Earlier in this chapter in connection with the Nizamsagar reservoir we referred to the harmful practice of cultivating the sloping land on the fringes of reservoirs. Silt eroded from such areas flows directly into the reservoirs. It is necessary to prevent this by providing a protective belt at least 200 m. wide, on the periphery of the F.R.L. We recommend also that if necessary, the area required for the protective belt should be acquired by Government and handed over to the Forest Department for afforestation. It would be ideal if soil conservation work in the catchment could begin simultaneously with the construction of a dam, so that a major part of the catchment area is protected by the time the dam is completed. This may not always be possible. It is, therefore, suggested that steps should be taken to ensure that at least a preliminary report of the required soil conservation measures is prepared along with the project report, so that this important work is not lost sight of. The need for carrying out investigations in this regard and the financing of the same, have already been dealt with in Chapter V.

Magnitude of the Problem

14.27 Soil conservation measures were taken up in the catchment areas of a few reservoirs in some States during the Second Five Year Plan, at the end of which about 986 sq. km. (380 sq. miles) had been treated at a cost of Rs. 24.3 million. The areas covered were in the catchments of the D.V.C. dams, Bhakra-Nangal, Machkund, Hirakud and Chambal. The Government of India allotted Rs. 110 million for the soil conservation programme in the Third Plan under a Centrally sponsored scheme for 14 projects. They are : The D.V.C. dams, Bhakra-Nangal, Machkund, Hirakud, Chambal, Mayurakshi, Kundah, Pohru, Tungabhadra, Ramganga, Dantiwada, Kangsabati and Ghod.

14.28 When the Fourth Five Year Plan was being prepared the catchment areas of 187 projects, covering 15,90,729 sq. km. (614,181 sq. miles) were studied in connection with formulating a programme of soil conservation. Projects with catchment areas of less than 2,590 sq. km. (1,000 sq. miles) which were expected to be covered by the normal soil conservation and afforestation programmes of the States were omitted. Also excluded were barrages and weirs, works constructed upstream of other projects and some old schemes with apparently stable catchments. The following 8 new projects were finally included in the Soil Conservation Programme for the Fourth Plan : Nizamsagar, Nagarjunasagar, Matatila, Beas (Unit II), Mahi (Stage I), Ukai, Pochampad and Lower Bhavani. Depending on the additional information made available by the States and the Union Ministry of Irrigation & Power, it was decided that other projects could be included later.

14.29 The Directorate of Soil Conservation in the CW&PC has estimated that the catchment areas of 13 projects continuing from the Third Plan, excluding the Kosi, would be about 204,610 sq. km. (79,000 sq. miles). The interpretation of aerial photographs of this area has shown that from 11 per cent to 39 per cent of the catchment (average 25 per cent or roughly 51,230 sq. km.) requires immediate attention. Similarly, it has been estimated that 25 per cent or 113,313 sq. km. of the 453,250 sq. km. forming the catchment of the eight projects which have been included in the Fourth Plan would need intensive treatment. The cost of treating 13 old and the 8 new projects would be of the order of Rs. 8,000 million, at Rs. 49,000 per sq. km. based on figures given by the Union Ministry of Food & Agriculture. Even if we allow for a certain degree of overlapping, as in the case of projects upstream of the Nagarjunasagar and Pochampad reservoirs, the problem facing the country is formidable. A more accurate assessment of the untreated catchment area of individual projects would serve to reveal the exact dimensions of the problem.

A time-bound programme of soil conservation appears to be necessary and we feel that the programme should be completed in a period of twenty years. However, in those projects where the problem is acute, a ten-year programme should be drawn up.

Administrative Arrangements

14.30 The administrative arrangments for implementing soil conservation and afforestation programmes vary from State to State. In some, like Orissa and Gujarat, the work is shared between the Forest Department and the Department of Agriculture; in others like Tamil Nadu and Andhra Pradesh it is shared between the Forest Department, the Public Works Department and the Agriculture Department. Though different soil conservation works are attended to by different departments, in States like Mysore, Rajasthan, Tamil Nadu and Andhra Pradesh, the overall responsibility for implementation of the programme is entrusted to a single department, either Forest or Agriculture.

14.31 Experience has shown that if a single department is in overall charge of soil conservation under a whole-time Project Officer, the results are satisfactory, and the problems of coordination are adequately dealt with.

We recommend, therefore, that wherever it has not already been done, the execution of soil conservation programmes should be put under a single administrative authority with a whole-time Project Officer. Technical units drawn from the different departments concerned should work under the Project Officer.

14.32 Where inter-State river valley projects are involved, a co-ordinating agency is necessary. One such agency, the Inter-State Soil Conservation Board in the Bhakra-Beas Project was set up in 1960 and functioned for some years. In the Machkund Project, an Advisory Committee was formed to control the programme in the catchment which covered Orissa and Andhra Pradesh. But it met too infrequently to be effective.

14.33 In 1953, a Central Soil Conservation Board with advisory functions was set up by the Government of India to guide soil conservation programmes. It was wound up in 1968, after the four zonal committees set up in 1965 for river valley projects had been found to function satisfactorily. These Committees, are presided over by the Inspector General of Forests and consist of Central and State Government officers. In our opinion, these committees are satisfactory co-ordinating agencies.

In addition, where there are Control Boards they too can perform a similar co-ordinating function. Where no Control Boards exist, or after such Boards have been dissolved, technical committees consisting of senior officers drawn from the State Departments of Forests, Agriculture, Irrigation etc. should be made responsible for the co-ordinated implementation of soil conservation programmes.

We recommend, therefore, that soil conservation work in river valley projects should be reviewed by Control Boards during their tenure; and where no Control Boards exist, technical committees of officers should be formed to review the progress, to effect co-ordination and to ensure efficient implementation of the programmes.

Legislation

14.34 In 1955, a Model Soil Conservation Bill was circulated to the States and in the last fifteen years, all States except West Bengal, Assam, Andhra Pradesh, Maharashtra, Gujarat and Himachal Pradesh, have enacted legislation based on the Model Bill. In Maharashtra and Gujarat, soil conservation works are covered by the provisions of the Bombay Land Improvement Schemes Act, 1942, and in Himachal Pradesh they are covered by the Himachal Pradesh Land Development Act, 1954. In Andhra Pradesh soil conservation work is now covered by the Madras Land Improvement Schemes (Contour Bunding and Contour Trenching) Act, 1949 in the Andhra area and by the Hyderabad Land Improvement Act, 1953 in the Telengana area.

14.35 In West Bengal and Assam, there is no legislation dealing with soil conservation. We recommend that soil conservation laws in the States should be reviewed to assess their adequacy, and in West Bengal and Assam suitable Acts should be passed. The legislation in all cases should contain provisions to enfore restriction on land-use and on grazing. It should also contain provisions enabling the executing agencies to apply soil-conservation measures to private land, and in particular to blocks of highly eroded stream banks, gullies etc. and the Government should be empowered to take over such land for the purpose.

Financing of Soil Conservation Measures

14.36 As mentioned in para 14.29 the cost of implementing soil conservation measures in 25 per cent of the catchment area of 21 centrally sponsored river valley projects would amount, roughly, to Rs. 8,000 million. The total expenditure on soil conservation in river valley projects up to 1968–69 was only Rs. 235.4 million and in the Fourth Plan an

additional Rs. 270 million has been provided. At this rate of expenditure, soil conservation, even on the 21 projects already taken up, will be delayed till most of the reservoirs will either have silted up, or lost a major part of their capacity. If, as we have suggested, soil conservation works in these river valley projects are to be completed in twenty years, the financial outlay on them will have to be increased substantially. If money for all the projects is not available, additional funds should certainly be provided for those reservoirs which are faced with serious silting problems. Sedimentation studies in selected reservoirs have shown that some of them have a very short span of life. Details of these reservoirs are given in Table 14.2 below :

Table 14.2
Sedimentation Studies in Selected Reservoirs

S. No.	Name of Reservoir	State	No. of years it would take to fill up dead storage
1	2	3	4
1.	Maithon	Bihar	50
2.	Panchet Hill	Bihar	33
3.	Mayurakshi	Bihar	25
4.	Tungabhadra	Mysore	22
5.	Ramanga	Uttar Pradesh	44
6.	Ukai	Gujarat	53

14.37 We recommend, therefore, that high priority be given to the above mentioned projects and that funds should be allocated to protect their catchment areas.

14.38 We are glad to note that some States have, on their own, started to protect the catchments of river valley projects. Kerala, for example, is taking steps to protect the catchments of the Iddiki, Neriyamangalam, Sabarigiri and Malampuzha projects. In like manner, the Maharashtra Government has taken up the protection of the Ghod project, one of the five which were identified by a study group in 1962 as being highly vulnerable to soil erosion. In Tamil Nadu similar measures are being taken in the catchments of the Vaigai and Mettur projects, in addition to those in the Kundah and Bhavanisagar catchments, which are included in the centrally sponsored programme. In Orissa, work is in progress in the catchment areas of the Baitarni and Brahmani as well as in the Hirakud and Machkund catchment areas which were included in the centrally sponsored programme.

While appreciating the work done by some States, we recommend that all States should make an early assessment of the erosion problem in the catchment areas of reservoirs which are not covered by the centrally sponsored scheme. On the basis of the data collected, soil conservation should be taken up urgently in the catchment areas of the more vulnerable reservoirs.

14.39 The pattern of financial assistance for soil conservation in river valley projects in the Fourth Plan is 50 per cent loan, and 50 per cent grant. The cost of treating non-agricultural land is met entirely by the States. Whereas no part of the soil conservation cost is realised from tribal farmers in the Machkund catchment, in States like Mysore, Bihar and Gujarat, 75 per cent of the cost is recovered from farmers and 25 per cent is given as a subsidy. We found that many States, in working out the quantum of subsidy have added the cost of staff to the cost of work. The cost of the staff has been worked out on an *ad hoc* basis, as 25 per cent of the cost of work. This, in effect, means that practically the whole cost of the work is recovered from the farmer. We feel that soil conservation should be treated like any other development activity and the cost of staff should not be a charge on the farmer. Whatever charge is levied or subsidy is given should be worked out on the cost of works only.

14.40 Soil conservation measures vary from project to project. In some cases farmers have to switch over from growing agricultural crops to growing pasture grass or trees. Conservation on marginal land, on highly eroded land and gullies etc. which involve special treatment including structural works, may benefit individual farmers or the community as a whole. All these factors have a bearing on the amount of subsidy to be given. Some soil conservation works result in immediate benefit. particularly on irrigated land, and justify a reduction of the subsidy. However there are also other measures whose benefits are realised only after a period of time, and in such cases a somewhat larger subsidy would appear to be called for.

14.41 We are convinced that in order to enlist the farmer's cooperation, and to persuade him to take up soil conservation and follow-up practices, incentives in the shape of subsidies are necessary. However, for reasons which we have enumerated above, the scales of subsidy will have to be decided by each State Government, for each project. We do not, therefore, recommend any definite figure.

Silting of Canals

14.42 So far we have discussed the silting of reservoirs which trap the sediment brought down by rivers and provide relatively clear water for use in canals. The silting of canals in run-of-the-river schemes is a different type of problem. On many canals, such as the Sarda and the Western Yamuna, silt or shingle excluders have been installed to prevent excessive silt or shingle from entering the canal. Also on some canals silt ejectors have been provided to remove the bulk of any silt which may enter the canal. The problem of silt entry and its removal requires careful consideration at the time of formulating an irrigation scheme, since subsequent remedial measures are likely to be difficult and expensive. As an illustration, we would like to draw particular attention to the serious silting problem which exists on the Eastern Kosi Canal in north Bihar.

14.43 The Kosi river, rising in the Himalayas and traversing north Bihar to join the Ganga, carries an abnormally high sediment load during the monsoon months. Due to excessive sediment and the steep bed slope in the upper reaches of the flood plain, the river is unstable. It has been shifting its course and devastating vast areas in the process.

14.44 In order to confine the river to a set course and to provide irrigation to areas freed from the recurring ravages of flood, the Kosi Project was taken up in 1955. The project envisaged the construction of embankments on both banks of the river and a barrage at Bhimnagar on the Indo-Nepal Border, to control the river gradient, upstream, and provide a headworks for the Eastern Kosi Canal and later the Western Kosi Canal. The Eastern Kosi Canal is designed to carry a discharge of 425 cumecs. A power house is located about four kilometres from the head regulator. A silt-excluder is provided in the barrage adjacent to the head regulator. Although the Canal could draw its full supply with a pond level of $+245'$ at the barrage, the latter is so designed that if necessary the level of the pond could be raised to $+255'$.

14.45 The Eastern Kosi Canal was opened for irrigation in July 1964 with an initial discharge of 71 cumecs. The discharge was progressively increased in subsequent years and reached 303 cumecs in 1970. In spite of the silt excluder and judicious operation of the gates, the canal drew enormous quantities of silt which were deposited to a depth varying from 2.7m. (9 feet) at its head to 0.6m. (2 feet) some miles downstream. With the silting of its bed, the canal started eroding its banks and became much wider. It became necessary to clear the accumulated silt from the

head reach of the canal to enable it to draw the required supplies. The quantity of silt removed from the main canal between the years 1967 and 1971 was nearly 3.0 m.cu.m. The operations cost about Rs. 10 million.

14.46 A silt ejector has been constructed 686 m. below the head of the canal for getting rid of the sediment entering it. It was put into operation only in 1971 with a canal discharge of 283 cumecs, of which 71 cumecs was allowed to escape in operating the ejector. It has been claimed that 2/5th of the silt which entered the canal could be ejected through this device. There has been a proposal to build yet another silt ejector some distance downstream of the existing one. This is likely to improve the situation further; but it is doubtful whether this would provide a complete solution to the problem of running the canal with its full authorised discharge of 425 cumecs.

14.47 If the Eastern Kosi Canal is to function satisfactorily, an effective solution to its silting problem has to be found. The Kosi brings down a heavy silt charge mostly during the monsoon period. The winter flow is generally clear. It is obvious that the solution lies in (i) minimising the entry of silt into the canal, and (ii) removing the silt which does enter the canal. As regards (i), the canal should be run during the monsoon period only when it is necessary, to provide essential irrigation to crops. Fortunately the ayacut receives good rainfall. Rice is the main crop grown during this period. A switch-over from a long duration, season-bound variety to an equally high-yielding short duration time-bound variety, may help substantially in reducing the period of the running of the canal during the monsoon. As regards (ii), physical removal of deposited silt from the canal manually or with machines has to be done only as a last resort. Also, any measures for pushing the silt down the canal by steepening its slope and lining would only transfer the trouble from the head reach to the reaches below. Lining, however, would be desirable to prevent bank erosion. As an alternative to providing a second silt ejector, the feasibility of creating a stilling basin in the canal bed up to the power station might be examined. The silt deposited in this stilling basin could possibly be flushed back into the river during periods of low demand, particularly in the rabi season when the river water is generally clear and has a good silt carrying capacity. There may be a problem of maintaining the flushing channel on the river side beyond the embankment. The silt problem of the Eastern Kosi Canal is pressing and should receive urgent attention. The problem of silting will have to be seriously considered when the design of the Western Kosi Canal is being prepared.

CHAPTER XV

INTER-STATE RIVER DISPUTES

Definition

An inter-State river is one which flows through more than one State or which forms the boundary between two or more States. In questions relating to the sharing or utilisation of the water of inter-State rivers, the concept of a river valley or river basin which embraces the main river and all its tributaries, and includes the catchment of the main river and its tributaries, has to be borne in mind.

Major Inter-State Rivers in India

15.2 The major rivers of this country are almost all inter-State rivers. In the north-west is the Indus basin, which includes parts of India and Pakistan. In India, it includes Kashmir, Punjab, parts of Himachal Pradesh, Haryana and Rajasthan. In the extreme north-east is the basin of the Brahmaputra which includes Tibet, Arunachal, Nagaland, Meghalaya and Assam. The Ganga Basin includes parts of Himachal Pradesh and Haryana, Delhi, Uttar Pradesh, and parts of Rajasthan. Madhya Pradesh, Bihar and West Bengal. The Narmada and Tapi flow through Madhya Pradesh, Maharashtra and Gujarat; the Mahanadi flows through Madhya Pradesh and Orissa; the basin of the Godavari includes Maharashtra, Madhya Pradesh, Orissa, Mysore and Andhra Pradesh; the Krishna runs through parts of Maharashtra, Mysore and Andhra Pradesh, and the Cauvery through Kerala, Mysore and Tamil Nadu.

There are also smaller inter-State rivers like the Penner and the Mahi.

15.3 Most of these inter-State rivers have been dealt with at some length in Volume III where we have described the main features of their basins, emphasising the cardinal fact that each river basin is an entity, and that irrigation planning must take cognizance of this fact, and must therefore be related to the physical, meteorological and socio-economic features of the basin as a whole.

Fundamental Reasons for Conflicts

15.4 In all river basins there is a natural division between the upper basin, where the main river and its tributaries are born, and the lower basin through which the river finds its way either into a bigger river or into the sea. The upper basin, which contains the higher reaches of the main river valley and its catchment, is usually mountainous or hilly, and the lower basin is undulating or flat. As a consequence of the relative geographical position of the two divisions of a basin, and the differences in their topography there is usually a greater concentration of population, a more extensive and rather higher level of agriculture, and a more rapid overall development in the lower basin. All these factors stimulate the need for water.

15.5 As the upper basin develops and its population increases, its demand for water also rises. If the total volume of water available in the system is enough to satisfy the present and future needs of various parts of the basin, the question of sharing water presents little difficulty—although such matters as the submergence of land upstream of a dam, pollution, conservation of forests and preservation of wild life are possible subjects of dispute.

15.6 However, as often happens, if the volume of water in the river system is insufficient to satisfy the needs of various parts of the basin, there is likely to be a dispute. The lower riparians, naturally, wish to preserve, and protect their right to continue withdrawals at the rate to which they are accustomed by usage, and claim the benefit of the juridical principle of 'priority of appropriations'. The upper riparians, just as naturally, seek the endorsement of another juridical principle, that of equitable distribution', even if this means less withdrawal by the lower riparians, and they resist any claim which tends to retard or to inhibit their own development or curtails their use of water.

15.7 River flows can be used for the generation of power and for agricultural and industrial uses. However, because of the fact that rivers take their birth in the highlands of an area, the natural lie of the land implies that the resource—power or water—is usually with the upper basin, though the inhabitants of the lower basin too are heavily dependent on it. It is this situation which frequently lies at the root of inter-State river disputes.

15.8 In India, the rapid pace of development, particularly in irrigation and agriculture, has brought home to the States the importance of

river waters, with their immense potential as sources of power and irrigation. With so many rivers flowing through more than one State conflicts are bound to arise.

History of Legislation dealing with Inter-State Rivers

15.9 During the early years of British rule, and until the enforcement (in 1921) of the Government of India Act of 1919, irrigation works in India were, to all intents and purposes, under the control of the Government of India. The sanction of the Secretary of State was required for all irrigation projects costing more than Rs. 1.0 million, although the actual execution and management of sanctioned irrigation works was the responsibility of the Provincial Government.

15.10 In 1921, irrigation became a provincial but 'Reserved' subject. This meant that the major irrigation works were handled by Executive Councillors and were, therefore, under the ultimate control of the Secretary of State for India, whose prior approval was necessary for projects involving an expenditure of more than Rs. 5.0 million and for any project on an inter-State river.

15.11 The position was materially altered with the passing of the Government of India Act, 1935, when irrigation became a Provincial subject under the charge of a Minister and wholly within the legislative competence of the Province. Entry 19 in the Provincial Legislative List of the 1935 Act reads : "Water, that is to say, water supplies, irrigation and canals, drainage and embankments, water storage and water power."

15.12 Nevertheless, the responsibility of the Government of India continued to extend to inter-State disputes and the extent of this responsibility was elaborated in Sections 130, 131 and 132 of the Act. Thus, inter-State disputes were settled by the Governor-General who was empowered, if the issues involved were of sufficient importance, to appoint a Commission consisting of "persons having special knowledge and experience in irrigation engineering, administration, finance or law" to make recommendations on the basis of which a decision could be taken. A notable example of this was the Indus Commission set up in 1941 under the Chairmanship of Sir B.N. Rau to go into the dispute between the provinces of Sind and Punjab relating to the sharing of the waters of the Indus.

Article 262 of the Constitution

15.13 By and large, Independent India continued to observe the

division of responsibility with regard to irrigation which was laid down in the Government of India Act of 1935. However, with regard to inter-State rivers Article 262 of the Union Constitution of 1950 empowered Parliament to make laws for the adjudication of disputes. It reads as follows :

"(1) Parliament may by law provide for the adjudication of any dispute or complaint with respect to the use, distribution or control of the waters of, or in, any inter-State river or river valley."

Parliament was also given the power to pass a law barring the jurisdiction of the Courts by Clause (2) of the Article, which reads as follows :

"(2) Notwithstanding anything in this Constitution, Parliament may by law provide that neither the Supreme Court nor any other court shall exercise jurisdiction in respect of any such dispute or complaint as is referred to in Clause (1)."

Inter-State Water Disputes Act

15.14 By virtue of powers vested in Parliament by Article 262, it enacted the Inter-State Water Disputes Act, 1956. Section 3 of the Act lays down that "if it appears to the Government of any State that a water dispute with the Government of another State has arisen, or is likely to arise, by reason of the fact that the interests of the State, or of any of the inhabitants thereof, in the waters of an inter-State river or a river valley have been, or are likely to be, affected prejudicially by—

(a) any executive action or legislation taken or passed or proposed to be taken or passed, by the other State; or
(b) the failure of the other State or any authority therein to exercise any of their powers with respect to the use, distribution or control of such waters; or
(c) the failure of the other State to implement the terms of any agreement relating to the use, distribution or control of such waters,

it may request the Central Government to refer the dispute to a tribunal for adjudication."

15.15 Section 4 of the Act lays down that "when any request under Section 3 is received from the State Government in respect of any water dispute, and the Central Government is of the opinion that the water dispute cannot be settled by negotiations, the Central Government shall, by notification in the Official Gazette, constitute a Water Dispute Tribunal for the adjudication of the water dispute".

15.16 The Union Government is also empowered to enact laws under Item 56 of the First List to the Seventh Schedule which reads as follows :

"Regulation and development of inter-State rivers and river valleys to the extent to which such regulation and development under the control of the Union is declared by Parliament by law to be expedient in the public interest."

15.17 In exercise of powers under this item, Parliament enacted the River Boards Act of 1956, which authorises the Union Government to "establish a River Board for advising the Governments interested, in relation to such matters concerning the regulation or development of an inter-State river or river valley or any specific part thereof, and for performing such other functions as may be specified in the Notification".

15.18 The Act provided that a Board could be established for one inter-State river, or river valley, or for a group of inter-State rivers or river valleys, in consultation with the State Governments interested.

River Boards Act of 1956

15.19 The River Boards Act created a machinery and a 'modus' for investigating the water potential of a river basin, for collecting relevant data, and advising the State Governments concerned on the best means to develop the water resources of a basin. Though the functions of the proposed River Boards were mainly to advise the State Governments, they were expected, when tendering advice, to present the river basin picture as an all-embracing and comprehensive whole, and in a manner which would enable dicisions to be taken on the basis of the assessed facts, and in consonance with the water needs of the basin as an entity. Essentially, their function was to secure the largest possible measure of agreement among the States concerned, to the schemes which they proposed for the utilisation and distribution of the waters of the basin. The Boards were empowered to apportion the cost of development and to monitor the progress of work. When a River Board failed to secure agreement on any aspect of the advice tendered by it, or where any of the Governments concerned refused or neglected to undertake any measures in pursuance of such advice, or where disputes arose between two or more Governments with respect to any measures undertaken by any Government, in pursuance of advice tendered by the Board, or with regard to the sharing of benefits or financial liabilities arising out of such advice, the dispute could be referred to arbitration by any of the interested Governments.

15.20 The arbitrator was to be appointed by the Chief Justice of India, from among persons who are or have been judges of the Supreme

Court or are judges of a High Court. The arbitrator was empowered to appoint two or more persons as assessors to assist him. The arbitrator's decision was final and binding on the parties.

Issues in Inter-State Disputes

15.21 Broadly, the inter-State disputes which have so far arisen, centre round one or other, or a combination of, the following issues :

(a) The sharing of the waters of an inter-State river.

The dispute between Mysore, Andhra Pradesh and Maharashtra relating to the Krishna, that between Andhra Pradesh, Maharashtra, Mysore, Orissa and Madhya Pradesh relating to the Godavari, and between Madhya Predesh, Maharashtra and Gujarat relating to the Narmada are some examples.

(b) The apportionment of costs and benefits of a joint venture of two or more States.

On this issue there are disputes between Bihar and Uttar Pradesh relating to the Musakhand dam, and between Andhra Pradesh and Mysore relating to the Tungabhadra.

(c) The compensation payable to a State (usually an upper riparian State) which suffers damage through the implementation of a project undertaken by another (usually a lower riparian State). The compensation includes the cost of acquiring land on which to resettle those whose lands are submerged or otherwise damaged, and the other rehabilitation costs involved in such resettlement.

The question of compensation loomed large in the negotiations between the States concerned in the Bhakra-Nangal Project on the Sutlej, and the Pong Project on the Beas. In both cases, land in Himachal Pradesh was to be submerged.

It is one of the major issues involved in the current dispute between Madhya Pradesh and Gujarat relating to the Narmada, because the construction of a dam at Navagaon will submerge areas in Madhya Pradesh.

(d) The interpretation of an agreement or of the terms of an award.

The Cauvery dispute between Mysore and Tamil Nadu is one such case. According to an agreement arrived at in 1924 between the former Princely State of Mysore and the then Province of Madras, Mysore was entitled to extend irrigation to the limit of 45,000 hectares by means of reservoirs on the Cauvery and its tributaries, with an effective capacity

of 1,274 m.cu.m. The Madras Government was to limit the extension of irrigation under the Mettur Project to 122,000 hectares with the capacity of the Mettur dam at 2,648 m.cu.m.

The dispute between the States arose out of the interpretation of the agreement, as to what each State was permitted to construct on the rivers of the basin to further the development of its irrigation.

(e) Complaints relating to excess withdrawals of water.

One of the issues raised in the current dispute between Maharashtra, Mysore and Andhra Pradesh relating to the Krishna is that of alleged withdrawals by the States in excess of the interim re-allocation of water made by the Union Government pending a final allocation. Maharashtra has been accused of an excess withdrawal of water from the Krishna at Koyna, for the hydro-electric project and for other irrigation schemes.

Disputes not a Unique Feature

15.22 It must not be thought that conflicts of interest are a feature peculiar to co-riparian States in India, or that they have arisen only after Independence, or that they are a consequence of the nature of our Constitution, or, that they are, in any sense, a recent phenomenon. Inter-State disputes in the United States of America, for example, have kept jurists, courts and lawyers busy over the past seventy or eighty years, and individual disputes in that country have lasted forty to fifty years. Both the Government of India Act of 1935 and the Constitution of India of 1950, by making irrigation a State subject, and inter-State rivers a Federal or Union subject, have, to some extent, aggravated the problem. Disputes relating to the waters of inter-State rivers had risen long before the enforcement of the Government of India Act, 1935. To give only two examples; the dispute as to the sharing of Cauvery waters arose between Madras and Mysore as far back as 1909 and was ended by an agreement signed in 1924. The dispute has again flared up between the successor States of Tamil Nadu and Mysore. The dispute relating to the Palar river between Madras and Mysore was once resolved in 1892 by an agreement, only to be revived in 1927, 35 years later. It has continued since then in one form or another.

Disputes settled by Negotiations

15.23 Many States compete with their neighbours in the industrial, commercial and agricultural sectors. This competition often lies at the root of disputes regarding inter-State rivers. Increasing political sophistication, the rise in standards of living and the necessity to satisfy the

aspirations of the people, have all lent a new importance to issues which involve the use of water and power.

15.24 The fact that problems relating to the sharing of inter-State waters sometimes prove intractable, that the conflict of interest between contending riparian States has frequently defied amicable settlement through negotiation, and has called for the intervention of the Union Government or a recourse to adjudication, should not overshadow the success of the efforts at negotiation relating to the inter-State sharing of waters and the building of irrigation projects. Major projects like the Bhakra-Nangal, the Tungabhadra, the Chambal, the Damodar Valley, to mention only a few, are evidence of inter-State co-operation.

15.25 Projects now under construction, such as the Parambikulam Aliyar, which has been undertaken by Tamil Nadu to harness rivers which rise in Kerala; the Kokrapara Weir on the Subernarekha, where benefits are shared between the States of Orissa and Bihar, and the Gandak Irrigation & Power Project where the Indian States of Bihar and Uttar Pradesh on the one hand, and the Government of Nepal on the other, are involved, are current examples of successful negotiation leading to mutually beneficial agreements. They bear testimony to the high level of co-operation achieved between the States, notwithstanding the many thorny problems involved. In all these cases, the Union Government played a helpful and positive role.

15.26 The Union Government has set up, so far, only three Tribunals to adjudicate inter-State disputes. These are as follows :

(i) the dispute relating to the sharing of Krishna waters between Maharashtra, Mysore and Andhra Pradesh;
(ii) the dispute relating to the sharing of Godavari waters between Madhya Pradesh, Maharashtra, Mysore, Andhra Pradesh and Orissa; and
(iii) the Narmada Water dispute between Madhya Pradesh, Rajasthan, Gujarat and Maharashtra.

15.27 The Tribunals dealing with these disputes will take decisions on the merits of the claims made by the contending riparian parties, and it is not our intention to influence a decision in favour of one or other party involved in the disputes. However, we feel it to be our duty to examine the machinery for preventing disputes, and for solving them, when they arise.

Limitations of Adjudication

15.28 At present, with regard to inter-State disputes the riparian States in a river valley are free to reach agreement among themselves for sharing the river flows in the valley. Should no agreement be reached, the dispute can be referred to a Tribunal by the Union Government on a request from all or any of the States concerned. It is necessary to reiterate this position, because we are certain that the method of settling disputes by mutual agreement is undeniably the most satisfactory.

15.29 Legal systems, including our own, provide for the settlement of disputed issues by judicial, or quasi-judicial bodies, and usually such bodies deal adequately with these issues. However, disputes relating to the sharing of the waters of a river or a river valley are of such a nature that they cannot ordinarily be resolved by a judicial decision, to the satisfaction of the parties. Although the present law relating to these disputes provides for their reference to a Tribunal, in our opinion such a reference should be made only in the last resort. This is so because the issues in inter-State river disputes are seldom so clear-cut as to admit of unequivocal decisions. There are also a multitude of variable and imponderable factors which have to be taken into account, some of which already exist and some of which may arise in the future. For this reason, the apparently simple and justiciable issue of the sharing of waters, may get involved in a complex of socio-economic issues of greater moment than the simple, technical issues involved. Where the situation is fluid and subject to change, as in a rapidly developing river basin, the dynamics of change are such that any judicial opinion at a given point of time, however, well-considered and weighty, cannot but become out of date, or even inequitable, when, subsequently, the circumstances and conditions upon which it was based, have altered. For this reason, judicial decisions in the case of inter-State disputes tend to become the starting points for fresh litigation.

15.30 The power of Parliament to exclude the jurisdiction of the Supreme Court and other Courts, contained in Article 262 of the Constitution, was based on Section 133 of the Government of India Act of 1935, which had excluded all matters in respect of water rights from the jurisdiction of the courts. It is relevant to take note of the comments of the Joint Committee, made at the time when the Government of India Act of 1935 was being considered by the British Parliament. The Committee recorded that : "The Federal Court would indeed have jurisdiction to decide any dispute between two Provinces in connection with water supply, if legal rights or interests were concerned, but the experience of

most countries has shown that rules of law based upon the analogy of private property interests in water, do not afford a satisfactory basis for settling disputes between Provinces or States, where the interests of the Public at large in the proper use of water supplies are involved. It is necessary to emphasise the importance from the public point of view of the distribution of water in India, upon which not only the prosperity but the economic existence of large tracts depend."

15.31 In the International Law Association Conference at Helsinki in 1966, when the question of framing principles and laying down guidelines for the settlement of water disputes and the sharing of water between riparian States was taken up, it was recognised that adjudication was an unsuitable way to settle disputes relating to international waters. We cannot do better than quote what the Conference said : "Although certain disputes about international rivers and international river basins may lend themselves to third party adjudication under established international law, the maximum utilisation of an international drainage basin can more effectively be secured through joint planning. The great number of variables involved, the possibility of future changes in the conditions of the water-way, the necessity of providing affirmative conduct of the basin States, and the enormous complexity of a river basin make co-operative management of the basin greatly preferable to adjudication of each source of friction between the basin States."

15.32 The complexity of the issues referred to in this extract is evidenced by the factors which were recommended at the Helsinki Conference, for consideration in working out a reasonable and equitable share of a riparian State. These factors were :

(a) The geography of the basin including, in particular, the extent of the drainage area in the territory of each basin State;
(b) the hydrology of the basin including, in particular, the contribution of water by each basin State;
(c) the climate affecting the basin;
(d) the past utilisation of the waters of the basin, including, in particular, existing utilisation;
(e) the economic and social needs of each basin State;
(f) the population dependent on the waters of the basin of each State;
(g) the comparative costs of alternative means of satisfying the economic and social needs of each basin State;
(h) the availability of other resources;
(i) the avoidance of unnecessary waste in the utilisation of the waters of the basin;

(j) the practicability of compensation to one or more of the co-basin States as a means of adjusting conflicts among uses; and
(k) the degree to which the needs of a basin State may be satisfied without causing substantial injury to a co-basin State.

This list of factors was not exhaustive and the weight to be given to each factor was to be determined by its importance in comparison with other relevant factors.

15.33 It seems clear, therefore, that with so many complex issues involved, the method of agreement by negotiation is the most satisfactory, and that judicial pronouncements would not be able to deal adequately with these issues. Such pronouncements, notwithstanding their legal force, cannot carry the same conviction, nor give the same psychological satisfaction as agreements or compacts arising out of negotiation. Mutual accommodation and agreement go much further in the direction of ensuring equity, of redressing imbalances, and obtaining willing implementation, than judicial decisions, which more often than not, in spite of the probity and impartiality of the judge or arbitrator, have the effect of prolonging the agony of the riparian States. That the scope of mutual agreements often extends beyond what can be enforced by judicial decisions, is borne out by the history of successful negotiations in India, where compromise, mutual accommodation and even a willing sacrifice of interests to help solution, have led to many settlements.

15.34 The final settlement by negotiation, relating to the Gang Canal in the erstwhile Bikaner State, allowed water to be transferred from the river Sutlej for about 135 km., through the territory of Punjab to Bikaner State which was not a Sutlej riparian State. The Punjab Government constructed the canal solely for the purpose of irrigating land in Bikaner State, which now forms part of Rajasthan. It is difficult to see how a project of this kind could have been ordered by a court, or how the proceedings could have culminated, as they did, except as the result of mutual accommodation and agreement.

15.35 One more example should suffice. The Periyar Project was taken up in 1887. This was a bold and well thought-out scheme involving the diversion of the Pariyar which rose in the Western Ghats and flowed into the Arabian Sea. The aim was to make its waters flow eastwards, to irrigate some precarious districts in the State of Tamil Nadu. Only the willing agreement of the erstwhile State of Travancore, within whose confines the Periyar flowed, made the project possible. No court could possibly have compelled Travancore to allow this spectacular diversion of one of its rivers, for the purpose of assisting a non-riparian neighbour.

15.36 The many projects which we have mentioned earlier in this chapter, as having been the outcome of successful negotiations between co-riparians, all involved a certain amount of 'give and take', based on the shared desire of the parties to come to an amicable settlement, and their successful implementation depended largely on the fact that no party to the negotiations felt aggrieved.

15.37 We have been at some pains to analyse the reasons for the inadequacy of the judicial approach to the intricate problems of inter-State rivers. We feel that there is no essential, or substantial, difference between a decision of the Supreme Court or a High Court, and that of a Tribunal headed by a Judge of the Supreme Court or High Court, in the adjudication of a dispute. It is true that, procedurally speaking, a Tribunal is more informal; it need not strictly adhere to the rules of evidence; it can adopt a more flexible approach, and it can combine, in the persons of those who compose it, legal and technical talent which give it certain advantages. However, its awards, or decisions, labour under the same disabilities as those of a court, and the factors which militate against the willing acceptance of a court order also militate against the Tribunal's order. For one or the other contending party, there is an element of compulsion in a judicial order, to which it cannot be reconciled. The findings or awards of a Tribunal, no more than those of a court, can cover matters entirely dependent on goodwill and mutual accommodation.

15.38 The element of compulsion, of which we have spoken, may lead to a hardening of attitudes and delay final and mutually satisfactory settlement. In matters as complex as inter-State water disputes, even the most carefully worded judicial decision is susceptible of more than one interpretation. Ambiguities can be discovered by the ingenuity of lawyers, and made the basis for making a fresh approach to the court, or the tribunal. A good example is the dispute between the States of Arizona and California in the United States of America which arose over the sharing of the waters of the Colorado river. After negotiations and prolonged litigation over a period of fifty years, a compact was arrived at between the two States on the basis of which a decision was given by the U.S. Federal Court.

15.39 It follows that if adjudication is a poor substitute for negotiation, and if negotiation between States does not prove fruitful, there should be some machinery to bring about an agreement.

15.40 International experience and practice point to the need for

a machinery in the shape of a joint commission, or some such body, to facilitate a settlement. The functions of such a commission would include investigating the potentialities of a basin, collecting and collating technical and other data, and formulating schemes which would provide the basis for eventual agreement. There are several international river basin agencies in existence, including the European Commission for the Danube, the Central Commission for the Navigation of the Rhine, the International Water and Boundary Commission set up by Mexico and the United States of America, and the Niger River Commission, to name only a few.

15.41 The usefulness and importance of these Commissions stem from the fact that they have been set up not to compel decision, but to get objectively at the facts, leaving the facts to speak for themselves. At the very least, they perform essential clearing-house functions for evaluating and exchanging ideas, collecting and assembling data, formulating principles and suggesting 'gound rules' relating to such matters as the division or distribution of irrigation, navigation, power and flood control benefits, the criteria to judge the proper selection of projects, and the sharing of costs.

15.42 An authoritative and highly competent body entrusted with the functions we have mentioned is bound to create the sort of climate where negotiations can be fruitful. Such a body can present a sound basis of facts upon which a final settlement can be based. It can make recommendations, offer alternative courses of action, and help to define and limit the major issues in dispute. The value of an organisation of this nature also lies in its ability to disentangle minor from major issues and to focus attention on the real needs of each situation. Very often, ignorance of the true position relating to the potential uses of water in the various States of a river basin leads to misunderstanding, and it is in removing such ignorance that an impartial body can be helpful.

15.43 Moreover, it is not only in the early stages of planning for the development of a river basin that such a body is useful and desirable. As a basin develops under the stimulus of irrigation and power, fresh problems arise because of the dynamics of change. These may again generate friction, unless they are observed and analysed in time, and adjustments are made to accommodate them. This pre-supposes a constant and continuous process of re-assessment, re-appraisal and review, and a joint commission or other similar body, is the obvious mechanism for the purpose.

15.44 Firm arrangements, based on treaties which have to be ratified

by sovereign States are more difficult to achieve than agreements affecting two or more States within a single federal system, like that of the Union of India. The fact that in most cases the recommendations of international commissions of this sort are advisory, and that member Governments have the power of veto, has not in the least detracted from their usefulness. They have succeeded in spite of these limitations.

River Boards

15.45 The River Boards Act of 1956 was intended to create just the type of machinery which we have discussed. When the River Boards Bill was introduced in Parliament, the Government stated that one of the objectives of the legislation was "to make suitable provision for resolving the conflicts among State Governments and for achieving maximum results in respect of service, control and optimum utilisation of the water resources of inter-State rivers".

15.46 Subsequently, the Third Five Year Plan stated that "River basins especially those of the larger rivers, naturally extend beyond the boundaries of individual States. In some cases, the most suitable site for harnessing the water resources of a river involving, for instance, less submergence of land or smaller cost of construction, may lie in one State while the area receiving the irrigation or power benefits may lie in another State. For the integrated and economic development of water resources, arrangements for inter-State co-operation are, therefore, essential. The setting up of River Boards for important river basins as is envisaged in the River Boards Act, would enable a co-ordinated view to be taken of the needs of a river basin as a whole".

15.47 However, the Act remained a dead letter. Among the objections raised against River Boards were that they were too expensive; that their role was only advisory, and State Governments could reject or ignore their advice if it was politically or otherwise expedient to do so; that the existing practice of informal consultation between representatives of the States for the development of river basins was adequate, and such consultations would not gain in strength if they were held through the medium of River Boards. It was also argued that the Central Water & Power Commission (CW&PC) was competent to perform functions identical with those entrusted to the Board. The Commission would scrutinise State projects as hitherto and for administering inter-State projects, joint control boards could be established. If a dispute arose, it could be referred to a Tribunal under the Inter-State Water Disputes Act. What was most urgently needed was the speedy implementation

of projects. There was a danger that the River Boards would divert attention from actual work to academic discussions. Some States also felt that if River Boards were set up, it might lead to the reopening of already settled issues or to the slowing down of sanctioned schemes.

15.48 The view that the CW&PC which possessed the requisite experience, technical competence and adequate administrative machinery, could be entrusted with the work of preparing basin plans appears to have prevailed after the States and the Centre has agreed to set up River Boards for the Mahi, Narmada, Tapi and Mahanadi. In favour of this view it was said that since there were as many as fifty river basins, it would be too expensive to set up a River Board for each, and that the CW&PC could prepare Basin Plans much more cheaply. No steps were, therefore, taken to set up any River Board. The CW&PC, thereafter, submitted proposals for strengthening its organisation to prapare basin plans for rivers in Central India and in the Peninsula, at an estimated cost of Rs. 100 million during the Fourth Plan. The Planning Commission reduced the provision to Rs. 40 million. In 1966–67, the CW&PC asked for a sum of Rs. 4 million for that year. This was cut down by the Planning Commission to Rs. 0.4 million and by the Finance Ministry, thereafter, to Rs. 0.113 million.

15.49 In 1967–68, a token provision was made, and the functions of the CW&PC in regard to the preparation of basin plans were whittled down to the mere collection of data. It was argued by the Finance Ministry that Rs. 17.10 million would be sufficient for the collection of data and the preparation of basin plans over a nine-year period. The funds allocated were obviously insufficient and the CW&PC lost interest in the matter. Not a single basin plan has been prepared, so far.

The CW&PC, as the highest technical body in the country in the field of irrigation, power and flood control, has more than enough on its hands by way of designing projects and advising the State Governments. It can hardly be expected to deal with issues that may lead to inter-State water disputes unless it sets up its own equivalent of a River Board for each river basin.

Whatever may have been the reasons for the failure to set up River Boards, it would be unwise, in our opinion, to review the concept of River Boards and the River Boards Act at this stage. Nevertheless, the necessity to create a machinery for collecting and sifting hydrological and other data required for river valley projects and to lay down policy, remains as urgent as before. When inter-State water disputes cannot be resolved with the assistance of the CW&PC, some machinery to assist settlement is clearly called for.

River Basin Commissions

15.50 In Chapter XII, we have recommended the setting up of river basin commissions to assemble and analyse hydrological river flow and ground water data, to compile and analyse geo-hydrological data for ground water exploitation, to prepare river basin plans and to deal with any aspect of water resources development entrusted to them for study. The procedure suggested for preparing plans should guarantee their comprehensiveness and technical quality so that they may be acceptable to the States concerned. This is of great importance in the context of inter-State water disputes which at present tend to become protracted, because parties present their own data and the difficulty of reconciling conflicting data leads to prolonged delays. We have no doubt that the data collected and analysed by the river basin commissions, which will have been approved by the representatives of the concerned States on the Commission, would greatly facilitate the settlement of inter-State water disputes.

National Water Resources Council

15.51 We have also recommended the establishment of a National Water Resources Council as a policy-making apex body with adequate technical support. The functions of the council have been set out in Chapter XII. We trust that the Council will help to develop a national outlook in relation to water resources, and will infuse a spirit of mutual accommodation in inter-State relationships. A favourable atmosphere will thus be created for the settlement of inter-State water disputes.

15.52 However, we cannot ignore the possibility of a deadlock being reached in an inter-State dispute, notwithstanding the efforts of the parties concerned. Whether the reasons for the failure to reach a settlement are political or economic, the intervention of the Union Government would be necessary. In this context, we shall now proceed to discuss the commendable role of the World Bank in bringing about a settlement of the Indus Waters Dispute between India and Pakistan. The manner in which the settlement was reached in this dispute will indicate also what role the Union Government can play in helping to settle inter-State water disputes.

Indus Waters Dispute

15.53 The partition of India into the two independent States of India and Pakistan drew a line across the Indus basin. The dispute

regarding the waters of the Indus basin had reached a deadlock by 1952, when both parties accepted the good offices of the World Bank. When it was not possible to reconcile the conflicting claims put forward in the plans of the two countries, the Bank suggested a plan which finally took the shape of the Indo-Pakistan Treaty on the sharing of the waters of the Indus basin. The treaty as finalised in 1960, gave the eastern rivers (Ravi, Beas, and Sutlej) to India and the western rivers (Indus, Jhelum and Chanab) to Pakistan. A ten-year transition period was fixed, during which India would continue to supply Pakistan with such waters from the eastern rivers as were specified in the Treaty. India agreed to pay a fixed amount as its contribution towards the cost of replacement works in Pakistan irrespective of the ultimate cost of these works and in turn obtained the promise of a loan for the Beas Project from the World Bank and U.S.A. India's contribution of 174 million dollars to the cost of replacement works in Pakistan was balanced, to some extent, by a loan of 56 million dollars from the U.S.A. and the World Bank.

15.54 A major feature of the settlement was that Pakistan received from the World Bank, U.S.A. and other friendly Governments U.S. $ 691 million in grants and loans towards the cost of works undertaken in Pakistan for replacement and development. Later Pakistan received an additional sum of U.S. $315 million in grants and loans from the Bank and friendly Governments provided that Pakistan would accept this as "a full and complete discharge of all obligations whether legal or moral, express or implied" of the Bank and other Governments under the 1960 settlement.

Role of the Union Government

15.55 We do not think that it would be asking too much of the Union Government if we recommend that it should play a beneficent role in settling intractable inter-State water disputes on lines similar to those adopted by the World Bank in the Indus Water Dispute. In the past, the Union Government has accepted the role of mediator which is implicit in the wording of Section 3 of the Inter-State Water Disputes Act. In some cases, it has set up committees under the CW&PC to assist the States to reach an agreement. This procedure was followed in the dispute between Bihar and West Bengal on the Koymani waters, and in the dispute between Madhya Pradesh and Uttar Pradesh on the waters of the Ken river system. Similar committees had been set up for the Krishna, Godavari and Narmada systems.

15.56 The Union Government provides substantial funds for many of the Plan projects of the States, and it does so as much in the national interest as in the interest of the States concerned. It will, therefore, be conceded that the development of inter-State river basins and the settlement of inter-State river disputes are matters where the national interest is deeply involved. Frequently, the failure of inter-State negotiations is due to the fact that one or other of the States concerned feels that it is getting the worst of the bargain. In such cases, a settlement would depend on the ability or willingness of the more fortunate State to compensate the less fortunate State by a suitable *quid pro quo* or by a sacrifice of a part of its own claims.

A typical example of this was the outcome of the dispute between Madhya Pradesh and Rajasthan on the Chambal waters. The final settlement of the dispute owed much to the fact that the two Governments concerned, mutually agreed to forego compensation for Government property (except Government buildings requiring replacement) which was being submerged. The Rajasthan Government agreed to bear half the expenditure on the rehabilitation of the population displaced in Madhya Pradesh. In addition, to facilitate the construction by Madhya Pradesh of the Gandhisagar dam, several sq. kms. of territory in Rajasthan were transferred permanently to Madhya Pradesh.

15.57 There is also the complicating factor of politics. No State is willing to run the political risk of appearing to be a willing party to a questionable bargain. In such a situation, the benevolent intervention of the Union Government becomes inevitable. There are many ways in which the Union Government can intervene; but one or two hypothetical situations will illustrate what we have in mind. An inter-State dispute may arise, for example, when one State wishes to use the flows of a river for power generation whilst another would like to harness them for irrigation instead. If the Centre would be prepared to bear some part of the cost of putting up a thermal station for the generation of power so as to release the waters of the river for irrigation, it would certainly facilitate settlement. Or, where two riparian States claim the waters of an inter-State river for irrigation, a solution may possibly be found in transferring water from another basin where there is a surplus to meet the needs of one or other of the contending States. Here again, if a part of the cost of this transfer were to be borne by the Centre, it would facilitate agreement. Alternatively the Centre could help to finance a massive ground water development programme in one State so that the latter relinquishes its claim to the use of the surface waters in dispute.

15.58 It may be argued that attempts by the Union Government

to settle disputes on these lines would encourage intransigence and lead to a situation where the Union Government would be blamed if it were not in a position to give financial or other help to the parties to the dispute. However, such occasions are likely to be few. If the facts in dispute have been gone into thoroughly, the Union Government should not find it difficult to determine the extent to which it can legitimately be called upon in the national interest, to provide assistance.

15.59 We would recommend, therefore, that the machinery of river basin commissions should be availed of to marshall the facts and to clarify the issues involved in inter-State river disputes. Where it is necessary for the Union Government to step in, the endeavour should be to facilitate settlement by suggesting alternative schemes and by giving loans and grants or other forms of assistance to balance the scales, as was done by the World Bank in the Indus Waters Dispute.

15.60 What we have said in this Chapter should not be interpreted to mean that the Inter-State Water Disputes Act should be repealed or diluted. We have made out a case for exhausting all conciliatory efforts before referring disputes to a Tribunal appointed under that Act. If these efforts fail, then no option remains but to have the dispute decided by a Tribunal.

CHAPTER XVI

IRRIGATION ACTS AND CODES

Constitutional Position

Under the constitutional division of legislative powers between the Union and the States, the primary responsibility for the development of water resources rests with the States. Entry 17 of List II of the Seventh Schedule reads as follows :

> "Water, that is to say, water supplies, irrigation and canals, drainage and embankments, water storage and water power subject to the provisions of entry 56 of List I."

Entry 56 of List I, as we have stated in Chapter XV, confers upon Parliament the power to enact for the regulation and development of inter-State rivers and river valleys to the extent to which such regulation and development under the control of the Union, is declared by it to be expedient in the public interest. The only law passed by Parliament under this provision is the River Boards Act, 1956.

16.2 At present, there are various Irrigation Acts and Codes which regulate irrigation in the States. The list of such statutes is given in Appendix 16.1. The Acts vary because of the differences in irrigation practices in different parts of the country. These practices are influenced by such factors, as the incidence of rainfall, soil characteristics, topographic features and the agricultural practices of the people.

Irrigation Practices and Acts

16.3 In the northern States of Punjab, Uttar Pradesh, and Haryana, irrigation canals draw water from perennial rivers and run through flat country. There is little variation in the soil from the head to the tail-end of the canal. As water is comparatively plentiful, the canals are run continuously, distributing water to the irrigators in the command in proportion to their holdings. There are practically no restrictions on the crops to be grown, provided the water drawn by an irrigator is within his share.

16.4 The Northern India Canal and Drainage Act, 1873, as amended from time to time by different States, is applicable to the States mentioned above. It is a comprehensive legislation dealing with irrigation, navigation and drainage. It empowers the State Government to construct works for the use of surface water in rivers, streams and lakes for irrigation, to regulate the supplies of water from canals, to construct water courses and field channels to carry water from the outlets of the canals to the fields, to levy and collect water rates for the water supplied and to settle disputes regarding the construction and maintenance of water courses and the distribution of water among the co-sharers.

Under the Act, powers are conferred on Irrigation Officers to requisition compulsory labour in times of emergency, to prevent serious damage to irrigation or drainage works. For the purpose of protecting canals and drainage works from any damage or destruction, penalties have been prescribed. Further, it regulates navigation on canals. For ensuring the proper drainage of land, the Act empowers the State Government to construct field drains and drainage channels and to prohibit by notification the creation of obstructions in particular reaches of any river.

16.5 The Rajasthan Irrigation and Drainage Act, 1954, and the Jammu and Kashmir Canal and Drainage Act, 1963 are similar to the Northern India Canal and Drainage Act.

16.6 In the western region, Gujarat is governed by the Bombay Irrigation Act, 1879. Maharashtra is governed in Vidarbha and Marathwada regions by the Madhya Pradesh Irrigation Act, 1931 and the Hyderabad Irrigation Act respectively, and in the Bombay region by the Bombay Irrigation Act.

16.7 Unlike in the north, where water is plentiful, canals and other irrigation works in this region have to depend on storages. In areas where rainfall is low, the erratic nature of the monsoon leads to variations in the demand for canal water in a season and from year to year. As a result, the block system of irrigation prevails, under which a farmer has to decide in advance the crops which he would like to irrigate. For each crop he has to get the areas sanctioned by the Irrigation Department. Sanctions for the various crops are given on a long term basis i.e. six years or even longer. The farmers are required to apply for water before every irrigation season, and permits are issued to them specifying the areas to be irrigated.

16.8 In Maharashtra, all the three Acts mentioned above provide for the compulsory construction and maintenance of water courses.

The position in Gujarat is similar. The Bombay Irrigation Act authorises the levy of water rates for the water supplied, and penal charges for the unauthorised use of water. Betterment charges can be levied on land benefited by the construction or extension of a canal. Further, the Act empowers the levy of irrigation cess in respect of land under the irrigable command of a canal. Drainage schemes for the proper drainage of land, and flood protection can be undertaken under the Act. The Act also makes provision for the requisition of compulsory labour for protecting irrigation works in emergencies and makes punishable any damage to irrigation works. Enhanced penalties are provided for offences which endanger the stability of irrigation works.

16.9 In the eastern region, that is in West Bengal and Bihar, the Bengal Irrigation Act, 1876, for the most part regulates irrigation practices. It contains detailed provisions for the construction, maintenance and regulation of canals, for the supply of water and for the levy of water rates.

Under the Act, irrigators are required to submit individual applications on a prescribed form for getting water for every *fasal** or for a period of six years. The Act provides for the levy of water rates on water supply for irrigation. There are also provisions for cancelling the supply of water to cultivators who are in arrears with water dues.

In West Bengal, there are two methods of assessing water rates. One is on the basis of the areas and crops for which agreements have been entered into, irrespective of whether the areas concerned are actually irrigated. The other is a uniform rate levied annually for the entire area in the command of an irrigation work. In this case no field-wise, or crop-wise, irrigation is recorded. The Act contains elaborate provisions for the construction and maintenance of village channels,** but only at the instance of the beneficiaries. Disputes regarding the mutual rights and liabilities of persons in respect of the use, construction or maintenance of such village channels are covered by specific provisions. The Act provides for the construction of drainage works and also empowers Irrigation Officers to prevent the creation of obstructions in any notified reaches of rivers, streams etc. It lists a series of punishable offences relating to irrigation works and the supply of water therefrom. For acts endangering the stability of irrigation works, enhanced penalties are provided.

16.10 The system of irrigation management in the southern States of Tamil Nadu, Andhra Pradesh, Mysore and Kerala is based on the

*Fasal: crop season.

**Water courses and field channels.

"dry" and "wet" classification of lands. The localisation of crops is practised in these States under which a soil survey of the command area is carried out, the areas most suitable for different seasonal and perennial crops are determined once and for all and only such crop or crops as are prescribed for an area are allowed to be grown on it.

16.11 The linguistic reorganisation of the States changed the territorial composition of all the four southern States. Mysore became a bigger State with additions of territory from Maharashtra, Hyderabad and Tamil Nadu. Different irrigation statutes were applicable to different regions of the reorganised Mysore State. In 1965 Mysore enacted the Mysore Irrigation Act repealing several statutes which were in force in various parts of the State. Tamil Nadu has several statutes covering different aspects of irrigation management. This applies to Andhra Pradesh as well. Kerala also has two Acts, the Travancore-Cochin Irrigation Act, 1956, applicable to the Travancore-Cochin areas and the Malabar Irrigation Works (Construction and Levy) Act, 1947, applicable to Malabar.

16.12 The Mysore Irrigation Act is comprehensive, and highlights State control of irrigation management. For example, the State Government has the power to order that no irrigation work shall be constructed, controlled or maintained by a person without the previous sanction of the State Government. The State Government may control the construction of wells in any area in the interests of proper irrigation from any irrigation work. The Act confers powers on Irrigation Officers to decide in the public interest where the construction of channels should be and the most suitable alignment for such channels. Land required for channels is acquired by the Deputy Commissioner and vests, thereafter, in the State Government. Any beneficiary may either construct a field channel on this land with the permission of the Irrigation Officer or may ask the latter to construct the channel for him and at his cost. Arrears are collected as arrears of land revenue. The Act contains provisions for regulating the supply of water from irrigation works, cultivation on irrigated lands and the cropping pattern in the commanded area. Permission to use irrigation water can be given initially for a period not exceeding six years. Thereafter, the supply can be made permanent on an application by the beneficiary. Further, the Act contains provisions for the requisition of compulsory labour in emergencies. It empowers the State Government to take over private irrigation works for maintenance and to levy a cess on land benefited by any irrigation work maintained by it. It contains specific provisions relating to the safety of irrigation works such as the prohibition of mining and the excavation

of wells near irrigation works etc. Most offences in connection with irrigation works are cognizable.

16.13 Not only are there different irrigation statutes for different States, but in most States there is a multiplicity of laws covering various aspects of irrigation management and administration. The result is a plethora of statutes and rules which have to be mastered by irrigation officials if they are to function efficiently. The multiplicity of laws providing for multiple lines of authority and diversification of control for the operation and management of irrigation works diffuses responsibility and is against the interests of the State as well as of the irrigators. Irrigation works in certain areas of the same State continue to be administered by the laws applicable to these areas in their parent States prior to reorganisation. This naturally complicates matters. In order to avoid a multiplicity of laws and to ensure efficient irrigation administration, we recommend that the irrigation laws of each State should be consolidated into a single statute. Within the State the statute should apply uniformly to all regions.

16.14 We are of the opinion that it is possible to divide the country into four distinct regions, each with a fair degree of homogeneity, for purposes of irrigation administration. These regions roughly are : the North, comprising the States of Rajasthan, Jammu & Kashmir, Punjab, Haryana, Uttar Pradesh and Himachal Pradesh and the Union Territory of Delhi; the East, consisting of the States of Bihar, West Bengal, Orissa, Assam, Nagaland, Manipur, Tripura, Meghalaya and Arunachal; the West, comprising the States of Gujarat, Maharashtra and Madhya Pradesh; and the South, consisting of the States of Kerala, Tamil Nadu, Mysore and Andhra Pradesh.

The process of consolidating the existing Irrigation Laws which, we have recommended, as also the enactment of new laws would be facilitated if the Union Government were to frame model laws, to serve as a guideline for each of the regions described above. The States may make such variations as special circumstances may necessitate. This would ensure a degree of uniformity, at least with regard to the basic aspects of irrigation administration.

Ground Waters

16.15 The existing Irrigation Acts do not define the ownership of subsurface or ground water which is considered as belonging to the owners of the land. But in view of the vital importance to the nation of ground water for agriculture in different parts of the country, it is

essential for the Government to extend control over it and to provide for its methodical and systematic regulation in conjunctive use with surface water.

The Irrigation Act of Mysore contains provisions for control by the State over the construction of wells in areas where public irrigation works are constructed or are proposed to be constructed. When the State Government is of the view that in the interests of proper irrigation from any irrigation work constructed or proposed to be constructed, it is necessary to control the construction of wells in any area or areas, it may notify such areas. Thereupon no person can construct any well in the areas notified without the previous sanction of the Government, which may be given subject to such conditions as may be imposed by the Government.

Some states have enacted legislation regulating irrigation by tubewells.

In areas of plentiful ground water, such as the alluvial Indo-Ganga plain of the north and the deltaic plains of the south, the stage may not have been reached when the control of shallow aquifers say within 30 metres of the surface is necessary.

In the drought areas, with scanty ground water sources, the necessity to control all ground water may exist.

We recommend that State Governments should have the legal power to regulate ground water but may exempt waters down to a particular depth, say 30 metres in alluvial plains from control. The Union Government has already prepared a model bill for the control and regulation of ground water, and has circulated it to the States.

Supply of Water for Irrigation

16.16 The supply of water for purposes of irrigation is regulated differently under different statutes. Under the Northern India Canal and Drainage Act, water is supplied under the terms of a written contract, but if there is no contract or if the contract does not extend to any particular supply of water, canal water is supplied in accordance with the conditions laid down under the Act. No person entitled to use the water of any canal or any work, on land under the command of a canal or work can sell or otherwise let out or transfer his right to such use without the permission of the Superintending Canal Officer. However, all contracts between Government and the owners or occupiers of land for the supply of canal water are transferable, with permission. Irrigation rights shall be deemed to have been transferred with the transfer of land. No right to use water from any canal can be acquired by any person by prescription.

The Jammu & Kashmir Canal and Drainage Act and the Rajasthan

Irrigation and Drainage Act contain similar provisions.

Under the Bengal Irrigation Act, a written application has to be made for the supply of water, and a joint application can be made by two or more persons.

Likewise, under the Bombay Irrigation Act, for the supply of water, a written application has to be made to the Canal Officer. The right to use water can be transferred with the property to which water supply is permitted.

Under the Mysore Irrigation Act, two systems of water supply are current. One is the permanent supply for which a long and detailed procedure has to be followed, and which receives priority in getting water. The other is the system of temporary supply, which can be made only when there is surplus water after meeting the demands of the permanent holders of land.

Under the Madhya Pradesh Irrigation Act, which applies to Madhya Pradesh and the Vidharba region of Maharashtra, water may be supplied from a canal on demand under an *irrigation agreement*, to irrigate specified areas or to supplement the supply of water from a village tank or for industrial, urban and other purposes, or for the irrigation of compulsorily assessed areas. An irrigation agreement has to be entered into between the Government and the permanent holders of land according to the provisions of the Act. If permanent holders or occupiers of land in a village, mahal or *chak* apply for water, and if such holders or occupiers hold at least 2/3rd of land, if at least 95 per cent of the cultivators give their consent for entering into an agreement, the remaining land holders are deemed to have become parties to the agreement. The liability to pay canal revenue is fixed on all permanent holders of land irrespective of whether or not their lands receive irrigation.

The agreement provides for the irrigation of one or more specified crops. No claim can be made for compensation against the Government for any loss due to the failure or stoppage of water or for an excess supply of water. Irrigation agreements can be cancelled by mutual consent of the Government and the permanent holders owning not less than 2/3rd of the land or constituting not less than 95 per cent of the permanent holders or occupiers who were parties to the agreement. The Superintending Engineer may, after giving notice, cancel an agreement if the water courses are not properly maintained. The power to cancel agreements, without assigning any cause, is also vested in the Government. Such agreements are beneficial both to cultivators and the Government, as the Government is assured of its revenue and the cultivators of their water supply. Water can also be supplied on demand for areas not covered by agreements, if surplus water is available after meeting the requirements of agreements. The water rates for these supplies are generally higher than those under the agreements.

16.17 It would be observed that though there is no uniformity in the law and practice in the States for supplying irrigation water, the different laws and practices appear to be justified by the special circumstances of the various States.

Provision for Water Courses and Field Channels on the Irrigation System

16.18 The Irrigation Acts of the States provide for the construction of water courses and field channels. The definitions of water courses and field channels, however, vary from Act to Act. We are of opinion that the following definition which has been laid down by the Planning Commission should be adopted by the States, viz :

> "A water course is a channel, built at Government expense and maintained by the beneficiaries to convey water from an outlet to a hundred acre block or as may be prescribed."

> "A field channel is a channel built and maintained by cultivators beyond the water courses to serve the various fields within a block."

We are of opinion that the definitions are sound and should be adopted by all the States for the purpose of law and administration.

16.19 To expedite the construction of water courses, the Northern India Canal and Drainage Act was amended in Punjab by two amending Acts of 1958 and 1965 empowering the Divisional Canal Officer (D.C.O.) either *suo moto* or on the application of a shareholder* to prepare a draft scheme for the construction, extension or alignment of any water course or the realignment of any existing water course; the transfer of areas served by one water course to another; the lining of any water course or any other matter necessary for the proper maintenance and distribution of water supply from a water course. These are relatively minor matters which concern the administration of canal waters, and Canal Officers are best suited to decide disputes relating to them. Hence appeals are provided only to departmental officers, and the jurisdiction of the Civil Courts is barred.

16.20 In 1963 the Government of Uttar Pradesh amended the Northern India Canal and Drainage Act to ensure the speedy construction

*A person who is a shareholder in the land which is irrigated or is likely to be irrigated by a canal and also a person who is interested in the field drain.

of water courses and field channels. This amendment provided for the participation of *Gaon Sabhas* in the construction of water courses. If they failed to do it, the State Government was empowered to construct water courses on its own. After construction, however, all such water courses vested in the *Gaon Sabhas.* For the purpose of recovering the cost of land for water courses, the Government was empowered to collect a levy at the rate of one rupee per annum per hectare. Similarly to recover the cost of construction a levy of Rs. 1.50 per annum per hectare was permissible.

The implementation of the scheme, however, ran into difficulties. It took almost a year to complete the formalities prescribed by law, even if land for acquisition was available. In other States too, there are numerous genuine complaints of inordinate delays in the acquisition of land for water courses.

16.21 The Madhya Pradesh Irrigation Act provides for water course contracts between the State Government and the permanent holders and occupiers of irrigable land. Under the agreement the Government undertakes to construct water courses and to bear the cost of construction, though the responsibility for maintenance would rest on the permanent holders. The agreement can be entered into only by half or more than half of the permanent holders and occupiers, holding not less than two-thirds of such irrigable land.

The Act contains elaborate provision for the construction of field channels. It casts an obligation on every permanent holder and occupier of land receiving water from a field channel to maintain it in a proper state of repair. In case of default, the Executive Engineer can get the repairs done and recover the cost from the permanent holders or occupiers of land.

16.22 The Mysore Irrigation Act contains comprehensive provisions regarding the construction and maintenance of field channels, some of which are salutary. The Irrigation Officers can plan the construction of field channels and set in motion machinery for the acquisition of the land needed for the purpose.

We have discussed in Chaper VII how the development of the ayacut was held up under the Tungabhadra Project for want of field channels. The solution to overcome this difficulty adopted by the State Government was somewhat radical. In 1966 an order was issued that field channels in ayacuts of new projects would be constructed by the State as a part of the project. Further, ayacuts of irrigation projects were notified and irrigation in them made obligatory. These measures have considerably reduced the lag between the creation of potential and its utilisation.

16.23 There is no mention of water courses or field channels in the Bengal Irrigation Act. It mentions a village channel which takes water from a canal direct into the fields. It is clear, therefore, that the village channels of West Bengal include both water courses and field channels.

16.24 In Tamil Nadu, the Madras Irrigation Works (Construction of Field Bothies) Act, 1959, provides for the construction and maintenance of 'field bothies' which are small channels taking off from outlets in the Government channel. They convey and distribute water to individual fields.

The construction of field channels in Tamil Nadu also is the responsibility of the ryots, who are also responsible for the maintenance of these field channels, though the law does not expressly cast such an obligation on them. This appears to us to be an omission. We would like the law to be amended to provide that in case of failure on the part of the ryots to maintain the field channels, either an irrigation officer or a revenue officer, should have powers to carry out repairs to, and maintain, field channels and recover the cost of such repairs or maintenance from the beneficiaries as arrears of land revenue.

16.25 We have dealt separately above with typical cases of States in regard to the construction and maintenance of water courses and field channels. But there is no State where the irrigation law or a special law does not lay down provisions for the construction and maintenance of water courses and field channels. Generally the scheme followed is that the State Government has to acquire land for the construction of water courses and field channels for the land acquired for water courses, the State pays compensation but for land acquired for field channels, compensation has to be paid by the beneficiaries. The water courses are constructed by the State at its cost, but they have to be maintained by the beneficiaries. The field channels have both to be constructed and maintained by the irrigators. If the irrigators fail to maintain a water course, or construct and maintain a field channel, the Canal Department has the power to construct and/or maintain the work and recover the cost from the beneficiaries.

16.26 In practice, however, these elabotate provisions have failed to ensure the satisfactory construction or maintenance of water courses and field channels. The main obstacle appears to be the lack of a spirit of cooperation among irrigators who have to discharge the responsibility collectively, and the lack of funds, particularly on the part of small farmers. Another difficulty is the want of expertise and funds needed for constructing culverts or other works on water courses or field channels

when they cross a stream or road or cart track. Recommendations in this regard have been made in Chapter VII.

16.27 We recommend that the law and practice in regard to the construction and maintenance of water courses and field channels as it obtains in Punjab under the amended Northern India Canal and Drainage Act be examined by other States with a view to find out how far they can be made applicable to their territory.

16.28 Further, we recommend that the law relating to water courses and field channels should provide as follows :

(i) the water courses should be constructed by the Government at its cost, but the responsibility for their maintenance would rest on the beneficiaries;

(ii) the field channels should be constructed and maintained by the beneficiaries;

(iii) in case of failure to construct and/or maintain a water course or field channel, the State should have the power to undertake the construction and/or maintenance of such works and the cost may be recovered as arrears of land revenue;

(iv) the State should have the power *suo moto* or on an application made in this behalf by a majority of irrigators likely to be benefited and holding not less than fifty per cent of the land likely to be benefited, to construct field channels and recover the cost from the beneficiaries;

(v) the provisions of the Northern India Canal and Drainage Act as applicable to Punjab should be adopted for acquiring land for the construction of water courses and field channels; and

(vi) compensation for the land acquired for field channels should be recoverable prorata from the beneficiaries, on the basis of the area irrigated, and, as arrears of land revenue.

Drainage and Prevention of Water-Logging

16.29 Most of the Irrigation Acts empower State Governments to prohibit the creation of obstructions to the free flow of water in any notified river, stream or any artificial drainage channel. For instance, the Northern India Canal and Drainage Act, provides that whenever the State Government apprehends injury to any land, public health or public convenience due to obstruction of any river, stream or drainage channel, it may prohibit by notification the creation of any obstruction, or order the removal, or other modification of such obstruction. Similar

provisions exist in the Irrigation Acts of Bengal, Bombay, Madhya Pradesh, Orissa and Mysore.

16.30 The Orissa Irrigation Act empowers the Collector or an authorised Irrigation Officer, in cases of emergency, to effect the removal of obstructions even before the notification is published. The expenses incurred in removal can be recovered as arrears of land revenue. We recommend that similar provisions should be made in the Irrigation Acts of other States.

16.31 For the proper maintenance of drainage, the Canal Department must have power to construct field drains and drainage channels. Some of the Irrigation Acts contain provisions to this effect. However, no such provisions exist in the Irrigation Acts of Madhya Pradesh, Hyderabad and Orissa.

Under the Northern India Canal and Drainage Act, as amended in its application to Punjab, the procedure followed in the construction of field drains is the same as for field channels. It empowers the Divisional Canal Officer to prepare a scheme, publish it, and after giving a fair hearing to the parties affected, approve it with such modifications as he considers necessary. The Superintending Canal Officer may either *suo moto* or on an application made by an aggrieved party revise the scheme. The jurisdiction of civil courts is barred. Further, the Divisional Canal Officer is empowered to acquire land necessary for the construction of field drains without going through the procedure in the Land Acquisition Act. The cost of constructing drains is to be shared by the beneficiaries, according to rules made by the State Government.

16.32 The Punjab Government felt that fairly stringent provisions were necessary to prevent the spread of waterlogging. Other States with intensive irrigation systems are also facing or may face the problem of waterlogging. We recommend that the provisions of the Northern India Canal and Drainage Act as amended by Punjab should be adopted by those States in which waterlogging is apprehended.

Requisition of Labour in Emergencies

16.33 The Irrigation Laws prevailing in twelve States contain specific provisions for compulsory requisition of labour in emergencies. The States are Andhra Pradesh, Jammu and Kashmir, Uttar Pradesh, Punjab, Haryana, Maharashtra, Gujarat, Kerala, Madhya Pradesh, Rajasthan, Orissa and Mysore. The laws provide for compulsory requisitioning of labour in emergencies connected with the improvement, repair,

maintenance or annual clearance of silt in irrigation works. The power of requisition can be exercised only when adequate labour is not otherwise available. The Irrigation Acts of other States are silent on this matter.

16.34 A few statutes such as the Northern India Canal and Drainage Act, the Jammu & Kashmir Canal and Drainage Act and the Rajasthan Irrigation & Drainage Act, contain provisions empowering the State Governments to issue notifications, and thereafter exercise the compulsory power of requisition, either permanently or temporarily, in any area, for the purpose of effecting the annual silt clearance, or to ensure the proper operation of an irrigation or drainage work or to prevent it from being interfered with in a manner likely to obstruct the established course of irrigation of drainage. The Madras Compulsory Labour Act, 1858, for instance provides for the compulsory requisition of labour for urgent works relating to the protection of irrigation and drainage and also in enforcement of the local custom under which the village community is under an obligation to supply labour for the execution of irrigation and drainage works.

16.35 Compulsory requisitioning of labour is against human dignity and personal liberty. Article 23 of the Union Constitution specifically prohibits the requistion of forced labour except in case of compulsory service for a public purpose. We would prefer that the provision for requisitioning labour should be deleted. However, if any State considers this power to be necessary, the right to requisition labour should be limited to only sudden and extraordinary situations. The Commission, therefore, recommends that the existing laws for requisitioning labour should either be abrogated or revised to limit their application only to unforeseen and sudden breakdowns or breaches. It should not apply to annual silt clearance or to the normal maintenance of irrigation and drainage schemes. Further, the power should be exercised when labour is not otherwise available.

Protection of Irrigation Works and Unauthorised Irrigation

16.36 Acts of damage done to irrigation and drainage works come under the definition of mischief as contained in Section 480 of the Indian Penal Code. The offence is punishable with imprisonment which may extend to five years or with fine or both. The various State irrigation laws also contain drastic provisions including punishment by imprisonment, for damage to canal property.

The Commission, during its tours, was informed by canal officials

in Andhra Pradesh that while they could report a case of damage to revenue officials, the actual prosecution was conducted by the latter. They conveyed to us their feeling that revenue officials were not sufficiently vigilant in conducting prosecutions. Very much the same position exists in other southern States.

16.37 Proposals were made to us that the power to try cases of damage to canals and drains should be vested in Canal Officers. We cannot ignore the fact that Canal Officers are an interested party and we are averse to combining the right to prosecute, with the right to try the offender. Hence we do not recommend the vesting of magisterial powers in Canal Officers. We recommend, however, that among the serving magistrates of the district, one or more may be specially assigned the work of trying canal offences.

16.38 Almost all the Irrigation Acts provide for the recovery of penal rates for the unauthorised use of water. Generally, unauthorised use is done by cutting a canal or water course embankment. It is not always possible to identify the person whose act or omission has resulted in the unauthorised use of water. The law provides that, in such cases, a penal water rate can be levied on the occupier of land benefited by the unauthorised flow. The penal rates range from just the ordinary rate in some States, to as much as ten to thirty times the ordinary rates in others. An appeal against the assessment of penal rate by Canal Officers lies with the Collector. We recommend that the existing provisions for the assessment and recovery of penal rates for unauthorised use or wastage of water should be retained. Where the penal rates are low, they should be raised and made really penal. We would like to see more frequent use made of this power by the Canal Officers.

16.39 Almost all the laws vest in Canal Officers the power to stop canal supplies to any person responsible for the unauthorised use of canal water. The Commission noted with regret that while the Canal Officers were pressing for greater powers to punish unauthorised use of canal waters. adequate use was not being made of this salutary provision to stop canal supplies to offending parties. We are of opinion that stoppage of canal supplies, like cutting off an electric connection, is a very effective method of suppressing unauthorised irrigation. Hence we urge that the power to stop the supply of water to offending irrigators should be used effectively.

16.40 Though there is no dearth of legal powers, unauthorised irrigation is a growing menace. We deprecate the unauthorised use of water

as it enables the influential and powerful irrigators to benefit at the cost of weaker ones. In Chapter XII, we have made some further suggestions to overcome this menace.

Settlement of Disputes among Irrigators

16.41 The main areas where disputes among irrigators occur relate to the distribution of water, the obligation to construct, repair or maintain water courses and field channels, and the ownership and transfer of the right to water from water courses and field channels. Wherever the liability or responsibility is shared jointly, the incidence of such disputes is higher. Under the Northern India Canal and Drainage Act, as applicable to the States of Uttar Pradesh, Haryana and Delhi, if any difference or dispute arises among the irrigators regarding their mutual rights and liabilities in respect of the use, construction or maintenance of a water course, or water channel, any aggrieved person may apply in writing to the Divisional Canal Officer giving details of the dispute. The officer has the discretion to pass an order or to forward the case, after enquiry, to the District Collector for orders. The orders of the Collector relating to the use or distribution of water for any crop sown or growing at the time the order was passed, are final unless set aside by a decree of a civil court.

16.42 Punjab has amended the Northern India Canal and Drainage Act, and empowered the Canal Deputy Collector either *suo moto* or on an application by a cultivator to pass an order, after due enquiry, regarding the use or distribution of water from a water course among cultivators of any estate or holding. He can also pass orders regarding the use, construction or maintenance of a water course. His order, regarding the distribution of water for any crop sown or growing on the date of the order, is final subject to appeal or review. An appeal lies to the Divisional Canal Officer within thirty days of the date of the order. The Superintending Canal Officer has also the power to review the decision of the Divisional Canal Officer.

16.43 In Uttar Pradesh, Haryana, Delhi, Orissa, Mysore and Andhra Pradesh, the Irrigation Department and Revenue Department exercise dual control in the settlement of disputes. In Bombay, Bihar and Bengal, the Revenue Department disposes of disputes subject to judicial review by civil courts. The law as obtaining in Punjab regarding such disputes leads to their expeditious settlement. These disputes are of the nature of domestic differences and can be effectively dealt with by a departmental officer. We recommend that all the States should enact laws on the lines of the Northern India Canal and Drainage Act as amended for Punjab.

Further, appeals should be only to the departmental officers and in such disputes the jurisdiction of the Civil Court should be barred.

The Procedure for Assessment of Water Rates and Betterment Levy

16.44 In Chapter XI we have dealt with the economics and financing of irrigation works. Here we shall consider the procedure for the assessment of water rates as embodied in the various State Acts and Codes.

16.45 In a majority of the States the water rates payable by an irrigator are assessed by Canal Officers and the assessed amounts are recovered by Revenue Officers. In Orissa both the assessment and recovery are done by Canal Officers. In Madhya Pradesh and the Vidarbha region of Maharashtra, Irrigation Panchayats have been established for the collection of water rates and their remittance to the treasury. In Mysore, water rates are assessed as well as realised, by revenue officials. It would be preferable to follow a uniform practice in all States in matters pertaining to the assessment and realisation of water rates. We recommend that the Irrigation Department of the State should be made responsible for the assessment of water rates, but the recovery of the amounts assessed should be made by the Revenue Department. This practice will inter alia keep the canal officers in touch with the financial position of the works and hence of their efficiency.

The Role of Irrigation Panchayats and other similar Institutions in the Administration of Irrigation Systems

16.46 Some Irrigation statutes have entrusted certain aspect of irrigation administration to panchayats and cooperative institutions. Under the Travancore-Cochin Irrigation Act, local panchayats have been entrusted with the construction, repair and maintenance of all petty works which either irrigate, drain or protect an area of two hectares or less. In Uttar Pradesh, a part of the construction and maintenance of irrigation works is entrusted to the *Zila Parishads* and *Gaon Panchayats*. Under the Madhya Pradesh Irrigation Act, the Collector is given the power to establish an irrigation panchayat for a mahal or chak for which the permanent holders of land or the occupiers have entered into an agreement, or which comprises a compulsorily assessed area. The panchayat consists of one *sarpanch* and two or more members elected from among themselves by the permanent holders and occupiers who are a party to the agreement, or are compulsorily assessed. The functions of these panchayats are to assist the Irrigation Department by detecting and preventing encroachment on canal lands, by preventing damage

to irrigation works and by reporting any wilful damage caused to irrigation works. They also arrange for the construction of water courses, and for their repair and maintenance, settle disputes, collect canal revenues and remit them to the treasury.

16.47 Though the experience of entrusting certain functions of irrigation administration to the Panchayati Raj institutions and irrigators' cooperatives has not so far been satisfactory, we feel that some sort of body composed of irrigators created to share the responsibilities of irrigation would induce a sense of participation. The State Governments should examine the nature of organisations or societies of irrigators to be set up, whether the membership of such bodies should be compulsory or optional and the nature of duties to be entrusted to them. The powers may be given to them in stages. Certain incentives may also be found necessary. The Commission attaches high importance to the formation of these societies. The States may have to undertake legislation for the purpose.

CHAPTER XVII

RESEARCH, EDUCATION AND TRAINING

In the beginning irrigation research in India was neither organised nor institutionalised. Individual engineers made sporadic efforts; and on their own. Commendable research was done by them on subsurface flows, earthen channels and causes of silting. Among those who deserve mention are Col. J. Clibborn and R.G. Kennedy. Kennedy evolved the classic equations for designing channels, which were further developed by E.S. Lindley in 1919. Gerald Lacey established comprehensive formulae for designing stable channels in alluvial soils between the years 1929 and 1939.

17.2 Organised research began with the establishment of a Special Research Division in the Bombay PWD in 1916. This division did some valuable work in connection with the problems of land drainage and reclamation, canal losses, canal lining and improved irrigation methods. It also started working with hydraulic models and conducted experiments with standing-wave flumes and devices for energy dissipation below falls. It became the nucleus of the present Central Water and Power Research Station at Poona (CW&PRS).

In 1925, a research station was set up at Lahore, now in Pakistan. In 1938, another research station was established at Lucknow, followed by a field station at Bahadurabad in 1947. Other research stations or institutes were established in various parts of the country one of which at Roorkee later became the headquarters of irrigation research in Uttar Pradesh.

17.3 A number of major irrigation projects were launched under the Five Year Plans which necessitated the establishment of more research stations and the integration of their activities. As a result, irrigation research in India today is wholly institutional, done through bodies with a permanent staff and a hierarchy of workers. There are now 18 Irrigation Research Stations, two of which, the CW&PRS at Poona and the Central Soil Mechanics Research Station at New Delhi are run by the Union Government. Almost every State has a research station of its own.

17.4 Rivers in the flat alluvial plains of north India have large beds. To provide barrages and bridges across these rivers has always been a problem. Research with hydraulic models has, however, made it possible to narrow their waterways through guide bunds and thus effect economy. The flood embankments of the Kosi and the flood works on the Brahmaputra at Dibrugarh were designed after experiments with hydraulic models.

17.5 Research has helped to develop proper profiles for spillways and energy-dissipation arrangements in dams. The evolution of a roller-cum-ski-jump bucket design for energy dissipation at the Hirakud Dam was the result of intensive research at the CW&PRS, Poona. The design for deep-seated sluice outlets was also developed there.

Apart from the hydraulic aspects of dam design, experimental stress analysis has helped to determine complex stress patterns, which are not normally amenable to theoretical treatment. In the Bhakra Dam foundations, for instance, a 30 metre wide claystone seam was met, and it was necessary to excavate it and fill the trench with concrete. But there were conflicting opinions as to the depth of excavation. The problem was solved by photo-elastic experiments at the CW&PRS, Poona. A number of important studies have also been conducted in connection with foundation treatment, determination of foundation reaction, galleries, tunnels and other components of dams.

As a result of soil testing and model experiments, it has been possible to construct high earth dams.

17.6 One of the important achievements of irrigation research is the evolution of suitable designs for the foundations of diversion works on permeable soils. Proper silt-excluding devices have also been developed to minimise the entry of sediment into canals and channels.

17.7 Economical designs have been evolved for canal structures such as falls and cross-drainage works, energy dissipating arrangements, measuring devices and outlets.

17.8 Research on tubewells has been done to establish guide-lines for the design and construction of gravel-packed wells for maximum yield. The guide-lines prepared by the Uttar Pradesh Irrigation Research Institute have been accepted by the Central Board of Irrigation and Power (CBI&P) for use all over India.

17.9 Research, using the masonry testing facilities at Hirakud paved the way for the use of masonry in high dams such as the Nagarjunasagar.

Masonry construction is economical and labour-intensive. It suits Indian conditions, reduces dependence on machines and generates employment.

As a result of work done at various research stations, it has been possible to reduce the use of cement in mortar and concrete by about 20 per cent and to replace it by flyash or other puzzolanic material without any appreciable reduction in the strength, but with considerable saving in cost.

The Concrete and Soil Research Laboratory at Madras successfully evolved Ennore sand as the Indian standard sand, which is supplied to engineering research institutions and cement factories all over India resulting in a considerable saving of foreign exchange.

Co-ordination of Research

17.10 The CBI&P was set up by the Government of India in 1927, to act as a coordinating body in matters relating to irrigation in the Provinces. Over the years, it has been instrumental in coordinating the activities of the various research stations. It has also served as a clearing house for technical information and exchange of views between experts from various States.

17.11 The CBI&P in addition to an annual session holds a research session every year. Previously, reports of the various research stations were discussed at these sessions. Later on, as work increased, papers on specific research items came to be invited and discussed. Zonal meetings are also arranged by the CBI&P to discuss the programmes and activities of research stations in each zone.

17.12 Another important means of co-ordinating and disseminating information is the 'Irrigation & Power Journal' published by the Board. The Board prepares and circulates 'Irrigation and Power Abstracts' containing summaries of the latest developments in research all over the world. These journals are supplied to a large number of technical and research organisations in various countries.

17.13 In addition, the CBI&P functions as the National Committee for the International Commission on Irrigation and Drainage and the International Commission on Large Dams. It also acts as the liaison body in India for the International Association for Hydraulic Research. These organisations stand for international collaboration and co-operation and the CBI&P plays a pivotal role in disseminating the information supplied by them.

Basic and Fundamental Research

17.14 Till the beginning of the Second Plan, research in the field of irrigation and hydraulic engineering was largely confined to finding answers to specific problems. Experiments were conducted mainly to check the soundness of departmental proposals. Fundamental Research had received little attention. This shortcoming was removed when the CBI&P initiated a programme for basic and fundamental research relating to river valley projects and flood control works.

17.15 Twenty-five subjects covering the fields of hydraulics, soil mechanics and concrete technology, were identified as being of importance to the design, construction and operation of river valley projects. The study of these problems has been entrusted to various research stations, Central and State, including the University of Roorkee and the Indian Institute of Science, Bangalore. The expenditure incurred on the study is met by the Government of India as a Grant-in-Aid. Considerable progress has been made in the investigation of these problems and the findings have been of immense value in the construction of various irrigation projects.

Research in Future

17.16 Many projects of the future will be storage reservoirs involving the construction of dams at sites posing more complex problems than those encountered so far. Some of the new dams will have to be constructed in the Himalayas where the foundation conditions are poor and the hazard of earthquakes exists. At places it may be difficult to obtain proper construction materials within a reasonable distance.

Many of the complex foundation and structural problems may not be amenable to mathematical treatment and can only be tackled with the aid of models or experimental methods of stress analysis. Research will also be needed to facilitate the designing of structures which can withstand earthquakes. In this connection the commendable work done by the School of Research and Training in Earthquake Engineering in the University of Roorkee deserves mention. This School has been in existence for ten years and has undertaken research for projects like the Beas, Ramganga, Yamuna, Sholayar and Ukai dams. It participated in the study of the recent earthquake at Koyna and suggested measures to strengthen the dam. In view of the useful work being done by the School we consider that it should be given encouragement and support.

17.17 The heavy construction programme in the decades ahead will

be expensive. Research can play an important role in effecting economies by suggesting changes in design. Arch dams, buttress dams and multiple arch dams, are substantially cheaper, and it is just possible that one of the reasons why Indian designers have hesitated to take advantage of them is the absence of adequate research.

Standardisation can also lead to economy. The use of standardised precast members in various structures in a canal system not only reduces the cost but also improves the quality and speed of construction. Research stations working in close collaboration with design centres could do much to promote standardisation.

The cost of construction materials can be brought down through research. A case in point is the substitution of flyash for cement. It is always desirable to use local materials and cut down the cost of transport. If the local materials are not of the requisite specifications, efforts should be made to improve their quality through research. Soil cement and sand cement blocks making use of local soil or sand can be used in many places.

17.18 Very little work on hydrology has been done in our research stations. We still depend upon the empirical formulae developed decades ago to determine the rainfall-runoff relationship in catchments of different types. For want of adequate knowledge and data, the performance of reservoirs much as the Meshwa, Hathmati and Dantiwada in Gujarat and Walayar in Kerala has not been up to expectations. Research will have to be undertaken to establish a more accurate hydrological appraisal of water resources, which is the basic requirement for planning, designing, constructing and operating irrigation projects.

The perennial rivers originating in the Himalayas are fed by melting snows from the high ranges. A programme of glacio-hydrological studies is needed to ascertain the water potential and dependability of these sources.

Our knowledge of the vast sources of ground water is inadequate. We must know precisely what part of it is received from different sources, such as precipitation, seepage etc. Modern methods of assessing ground water resources with the help of analogue computers are coming into vogue. These methods will have to be further developed.

To maintain an equitable ground water balance, technical studies and research are needed to establish a correct hydrological equation between discharge and recharge. Correct spacing of deep and shallow tubewells and filter points, not only in relation to each other but also to gravity canals, will have to be determined.

We are informed that a proposal to set up a Central Institute of Hydrology is already under the consideration of the Government of India. The Commission supports the proposal and recommends that it should be set up without delay.

17.19 At present, there exists no advanced research facility to develop new designs for large pumps, high-head gates, valves and high-capacity hoists required for dams. In this field we are still dependent on foreign know-how. The Commission recommends that an advanced research centre for hydraulic machinery should be set up. To start with, one of the universities or institutes of technology could be assisted to set up a faculty for the purpose.

17.20 At present research facilities for the designing of complicated hydraulic structures are restricted to the CW&PRS, Poona. These facilities are not sufficient. The Commission recommends the setting up of a separate laboratory for structural design and analysis of complicated irrigation structures on the lines of the Instituto Sperimentale Modelli E Strutture (ISMES) Laboratory in Italy.

17.21 Rock Mechanics is a new field of study which has developed fast in the last 20 years. The science of Rock Mechanics is concerned with the behaviour of rock masses in relation to the design and construction of engineering structures. It will play a crucial role in works involving underground excavations for power plants, stability of rock slopes, stresses in tunnels, design of foundations for underground structures etc. It is, therefore, necessary to develop the requisite technology quickly. The small section for the purpose at the Soil Mechanics Research Station at New Delhi is too inadequate. The Commission recommends that this section should be expanded so that adequate research on rock mechanics can be taken up there.

17.22 Evaporation from open water surfaces is a serious problem in the case of the numerous shallow irrigation tanks dotted all over the country. It has been found that cetyl alcohol and its modifications like OED-70 offer effective means of reducing evaporation from open water surfaces. But the suitability and effectiveness of the process have to be tested more thoroughly under different conditions in India. The process is also very expensive. The Commission recommends that research on the application of substances like cetyl alcohol and the maintenance of mono-molecular or multi-molecular films under Indian conditions should be pursued; research is also needed to reduce the cost of the process.

The problem of the sedimentation of reservoirs has been dealt with in Chapter XIV. Research done so far indicates the need to revise many conventional concepts regarding the rate of flow and distribution of sediment in reservoirs. The Commission recommends that studies on sedimentation in reservoirs be intensified.

In the case of major irrigation works, the conveyance system consists of hundreds of kilometres of canals and channels, cutting across varied terrain with numerous natural drainage systems. The chief loss during transmission is through seepage from the beds and sides of canals and channels. Loss can be reduced by lining. There is scope for research to discover cheaper materials and methods. The Commission recommends that research connected with the lining of canals, channels and water courses, should be intensified.

Some canals and channels suffer from weeds which interrupt their free flow. At present, canals are closed for a few days and the weeds are removed by manual labour. Herbicidal treatment for the reduction of weeds is gaining prominence. 2, 4-D has been introduced. Before weedicides can be used on a big scale, however, safe levels need to be determined. The Commission recommends that research work be undertaken in connection with weed control.

17.23 The life of tubewells is often restricted to 15 to 20 years, because strainers get choked and other defects develop. As a result, replacement becomes necessary. The Commission recommends research to find ways of prolonging the life of tubewells.

17.24 The CW&PRS at Poona used the radio isotope technique successfully in tracing the movement of sediment in the Bombay Harbour. A few other research stations have also been conducting experiments in the use of radio isotopes for river discharge measurements, determination and tracing of seepage and soil compaction control, and in the use of analogue computers to assess ground water potential. The future of research will involve the use of such tools on a larger scale. Our research stations should therefore learn to make use of them.

There is need to improve instrumentation techniques so that :

(1) the accuracy of measurements is improved;
(2) speedy measurement becomes possible;
(3) personal errors in measurement are obviated; and
(4) new phenomena not clear with old and less precise instruments can be studied.

For example, it is visualised that with modern tools and instrumentation techniques, we should be able to measure discharge in a stream at any time, directly and speedily.

The performance of structures should be studied by embedding in them the appropriate instruments and by making a regular study. Pore pressures and settlement in earthen dams, temperatures, stresses, strains,

expansion and contraction in masonry and concrete dams, uplift pressures under barrage floors and stresses in retaining walls and arches could all be studied with advantage with such instruments.

The Commission recommends that existing Instrumentation Cells at research stations should be considerably strengthened and that new cells should be set up in every important research organisation.

17.25 In Chapter VI, the Commission has referred to new developments namely, (1) artificial rainfall, and (2) desalination. Both of them are of recent origin but have been found to be scientifically feasible. Operationally, however, they have been successfully established only in small areas under special conditions in some parts of the world. In India, not much research work has so far been done. We recommend, that research be undertaken to investigate the technical and economic feasibility of the artificial seeding of clouds and desalination of salt water under Indian conditions in various regions.

17.26 We have dealt with the water requirements of crops in Chapter VI. This is essentially a part of agronomy and the National Commission on Agriculture will we trust, make suitable recommendations for research on the various aspects of the crop-water relationships. However, no irrigation system can be properly designed unless the cropping pattern, and water requirements of various cropping systems have been worked out. The recent introduced high-yielding varieties require water to be supplied in right quantities and at the right time. The Commission, wishes to highlight the need for research into the following :

(i) The water requirements of rice in different soil and climatic conditions, in particular (a) to minimise losses by percolation and evaporation; (b) to determine optimum submergence and drainage; and (c) to study the comparative economics of direct seeding and transplantation.

(ii) The quantitative water requirements and the periodicity of supply to other high-yielding varieties of crops, such as wheat, cotton, hybrid-jowar, bajra, etc.

(iii) The evolution of multiple-cropping patterns specially in drought-affected areas where the availability of water is meagre.

Library and Documentation

17.27 Research efforts need to be supported by adequately equipped libraries and documentation facilities. Fairly well-equipped libraries are maintained by the CBI&P/CW&PC. But there is need for a substantial

extension of library facilities in different regions of the country. The aim should be to set up a net-work of interconnected libraries throughout the country. Such a system would help to ensure the speedy location and procurement of the required literature. As a first step towards this objective, the Commission recommends that the CBI&P/CW&PC library should be housed in a proper building and furnished with modern equipment and facilities.

17.28 A significant portion of the literature on irrigation originates from non-English speaking countries. Many books and periodicals in foreign languages are received from countries such as, U.S.S.R. and Japan. But irrigation engineers in India are often unable to benefit from them because translations in English or in Indian languages are not available. The Commission recommends that in due course the CBI&P/CW&PC library should establish a regular translating service. The Library should also provide an effective documentation service.

Personnel of Research Stations

At present, there are two systems for manning the Research Institutes.

17.29 In the first, the technical staff of research stations is drawn from the general cadre of the Irrigation or Public Works Department. Officers from the departmental cadre are posted to research stations where they serve for periods varying from three to five years and, in exceptional cases, for longer periods. The advantages of this system are (1) that there is frequent exchange of personnel between the department and the research station leading to a healthy understanding of both field and research problems; (2) that there is no stagnation in the promotion and prospects of research personnel, because even if no suitable posts are available in the research stations, the person concerned can still be promoted under the 'next below' rule or transferred and posted elsewhere. The disadvantage of this system, is that due to frequent transfers it is difficult to accumulate expertise in any field. As a result, the research output of the station suffers, because fresh incumbents take time to pick up the threads of research.

17.30 In the second system, the technical staff of the stations is treated as a separate cadre. This arrangement avoids frequent changes in the staff and enables the accumulation of expertise. However, in view of the limited opportunities for promotion in the small cadre deployed in research stations, there is stagnation at various levels which leads to discouragement and discontent.

17.31 It is essential to ensure that experienced and trained personnel who have developed expertise in the methodology of research and have made valuable contributions, are not lost to the research stations. Various suggestions have been made to provide necessary incentives to research workers. These suggestions include, (1) the creation of an All-India Service of Research Engineers or the inclusion of all the research posts in the Indian Service of Engineers, when formed, (2) providing continuous time-scales to research workers, with efficiency bars so as to ensure that at least increments in pay are not denied to research personnel for want of superior categories of posts, (3) other schemes for the recognition of merit in research such as merit promotions, advance increments, award of medals, etc.

17.32 After a good deal of thought we have come to the conclusion that the research stations should be manned by persons drawn from the departmental cadre, as irrigation research is mostly in the nature of applied research for which alternating field experience is necessary. Only suitable men with a known aptitude for research should be selected. A special research allowance could be given to them so that they remain attached to research. Normally, they should be retained in research for a period of at least five years before being transferred. If they become due for promotion while they are attached to the research stations, they should be promoted. We feel, however, that there should be no bar to the recruitment of pure scientists, to deal with special problems.

17.33 The need to develop instrumentation for advanced research has already been emphasised; but this development will not be possible until personnel properly qualified in electronics are employed. The existing general scales of pay are not good enough to attract such experts. Special pay scales for electronic engineers should, therefore, be introduced. As these persons will not be a part of the regular cadre of the research institute and they will not have adequate opportunities of promotion they should be offered a special time-scale of pay.

17.34 The cadre strength of the research institutions should be fixed so as to provide adequately for deputation, leave and training reserves. Unless this is done, the deputation of officers as consultants to other organisations in the country or abroad will have to be restricted; leave for periodical rest and recuperation, so essential for alertness in research work, will have to be refused, and the training of officers to keep them abreast of rapid developments in technology will suffer.

17.35 There should be ample opportunity for research workers to

enhance their qualifications by joining part-time classes in the discipline in which they are working, or in a subject which, in the opinion of the head of the institute, will increase their efficiency. The basic work done at the institute should be recognised by universities so that the staff may be able to enroll themselves for Post-Graduate Degrees.

17.36 Suitable arrangements should be made for the timely publication of research findings.

Co-ordination with Research in Higher Institutions of Engineering

17.37 Some Universities and Institutes of Technology do considerable research which can be of use to irrigation engineers. The research in earthquake engineering carried out by the Roorkee University has been mentioned already. In the planning of projects greater use should be made of the research expertise available at the higher institutions of engineering. The Commission recommends that such institutions should be entrusted with research on those aspects of projects in which they specialise. Further, the CBI&P should ensure collaboration and co-operation between the research activities of educational institutions and the research stations.

Finance

17.38 Expenditure on Applied Research in connection with the construction of projects is met from the estimates of the projects concerned; but the Fundamental and Basic Research Programme in the various irrigation research stations is financed wholly by the Government of India. Grants-in-Aid are released by the Government on the recommendations of the CBI&P.

17.39 While determining the size of the grant to be made for such programmes it must be recognised that some may not give an immediate or direct financial return. What is needed, therefore, is a liberal approach, so that research is not hampered merely because of the high expense involved. It is necessary to foster a climate which will encourage innovations and the growth of new ideas. One of the main considerations for research is that continuity of effort should be ensured. To this end, the Commission recommends that the research stations should be assured that the funds allocated for investigation after due pre-budget scrutiny will continue to flow according to the needs originally envisaged or as may be required during the progress of the investigations.

17.40 The powers of the heads of research stations are the same as those of similarly placed departmental officers, with regard to the purchase of books, import of scientific equipment etc. The powers of heads of research stations should be considerably enhanced in these matters. They should have more freedom to acquire technical books than their departmental colleagues. When a part of an instrument breaks down the research station should be allowed to import it if necessary, so that the instrument is not kept idle. It should also be allowed to import new instruments up to a specified aggregate value.

Education and Training

17.41 The Irrigation Engineer is basically a hydraulic and structural engineer and he remains so throughout his career. But irrigation aims at getting the maximum food and fibre out of the land. The Irrigation engineer should, therefore, acquire some knowledge of agriculture so that he is able to put water to the best use. To be successful he must have a basic knowledge of agronomy and plant science. The education and training of an irrigation engineer should, therefore, include a basic training in agriculture.

17.42 Some engineering institutions have already taken the necessary steps to impart education in agriculture. For example, the University of Roorkee in its syllabus of irrigation engineering for the Bachelor of Engineering courses, has included such subjects as 'Soil moisture and crop-water relationships, factors governing the consumptive use of water; methods of application of water; principal Indian crops, their seasons and water requirements; and the use of manures and fertilizers for increasing yield'. Subjects connected with land management such as 'Water-logging and Drainage' have also been included in the syllabus. The M.E. (Civil) syllabus of that university includes more detailed courses in these subjects. The Commission recommends that engineering institutions which have not done so, should add subjects connected with agriculture as indicated above to their syllabus of irrigation engineering. We further recommend that a new entrant to the Irrigation Department should be given a short practical training in an agricultural research station. He should also work for a short period in the Revenue Department to acquaint himself with matters relating to land acquisition, assessment of revenue and allied matters.

CHAPTER XVIII

IRRIGATION STATISTICS

At present, irrigation statistics form part of land utilisation statistics. They have a special relevance to the planning of irrigation projects and to their design and maintenance.

All-India Irrigation Statistics

18.2 Irrigation statistics at the national level are compiled and published by the Union Ministry of Agriculture through its Directorate of Economics and Statistics. The material for compilation is supplied by the State Governments and forms part of the land utilisation statistics. The irrigation statistics include the net area irrigated from different sources—public and private canals, tanks, tubewells, wells and other sources. They also include the gross irrigated area under different crops. For some crops such as rice, jowar, other millets and pulses grown in more than one crop season, the season-wise break-up is also indicated.

18.3 The Central Water and Power Commission (CW&PC) also collects, compiles and publishes statistics relating to major-medium irrigation works. It brings out two publications—(1) An annual 'Financial Statements of Irrigation Works in India' which contains statistics of the area irrigated, revenues collected and expenses incurred on major-medium works; and (2) A quinquennial statement of 'Irrigation Statistics' giving information on the engineering aspects of major and medium works and their financial results and physical performance. The publication of 'Irrigation Statistics' has, however, been intermittent. The latest publication covers data for 1960–61 only. We consider 'Irrigation Statistics' to be a useful publication and recommend that the CW&PC should bring it out regularly. State Governments should furnish the required information to the CW&PC in time so that this document may be published within 12 months from the close of the year to which the statistics relate.

18.4 The States employ two agencies for the compilation and main-

tenance of irrigation statistics for the State—(1) The Land Revenue/Land Records Department, and (2) Irrigation/Public Works Department. These statistics are collected at the village level and pass through more than one intermediary agency before being submitted to the State Government or the Chief Engineer. The statistics of the Revenue Department form part of the land utilisation statistics, but the Irrigation Department's statistics are independent and meant primarily for the assessment and collection of water rates. The Revenue Department's statistics include areas irrigated both by public and private works, but those of the Irrigation Department are limited only to public works. The Revenue and Land Records Departments publish their statistics in the form of Season and Crop reports. The statistics collected by the Irrigation Department are published in their Annual Report.

Primary and Intermediary Agencies in Collection of Irrigation Statistics

18.5 The Revenue/Land Records Department uses the services of the village Patwari* for collecting the basic data. He collects statistics on various aspects of land-use including irrigation and inscribes them in what is known as the 'Basic Village Form'. The Form is prescribed by the Land Records Manual of the States. Information in this form is inscribed after a survey of each field, that is, on the basis of a complete enumeration. Statistics relating to each item are added up in the Village Abstract and passed on to Tehsil/Revenue Circle Headquarters. The Tehsil-wise returns are consolidated into a District Return at the District Headquarters and forwarded to the State Government. The collection of statistics by the Patwari is supervised by the Supervisor Kanungoes or Circle Revenue Officers. The District Statistical Officers also supervise the work of the Patwaris.

18.6 The system of collecting statistics described in the preceding paragraph obtains in all the States except Kerala, Orissa and West Bengal. In these latter States, land-use and crop statistics are collected through sample surveys which give estimates for the whole State or for some districts. These statistics are highly inadequate. The Union Ministry of Agriculture has, for a long time, been pressing these States to make suitable arrangements for collecting statistics after the survey of each field as is being done in other States, but without success. In the result, irrigation statistics of these States are only approximations. The Com-

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*Also known as 'Lekhpal' in Uttar Pradesh, 'Karnam' in Tamil Nadu and parts of Andhra Pradesh, 'Talathi' in parts of Andhra Pradesh, Maharashtra and Gujarat, 'Karamchari' in Bihar and 'Mandal' in Assam.

mission recommends that the system of surveying each field for reporting land-use statistics should be introduced in West Bengal, Orissa and Kerala and the primary agencies there should be adequately strengthened for the purpose.

Contents of Statistics

18.7 Under the instructions of the Union Ministry of Agriculture, the States are required to collect the following statistics :

(i) Crop acreage, irrigated and unirrigated;
(ii) Sources of irrigation—canals, tanks, tubewells, wells and others; their classification according to ownership i.e., whether owned by Government or by private persons;
(iii) Classification of wells into masonry or non-masonry, in use or abandoned, whether used for irrigation or domestic purposes etc.;
(iv) Method of water supply, lift or flow; lift by electric pump or oil-engine or traditional devices; and
(v) Capacity of irrigation and extent of the irrigated area—for a canal, mileage; for a tank, whether the ayacut exceeds 40 hectares or is 40 hectares or less; and for a well whether it has an independent ayacut or it supplements other sources of irrigation.

The information is to be entered in the Basic Village Form. Although the Union Ministry's instructions have been accepted by the States in principle, yet most of the States have not started collecting all the information mentioned above.

Delays in Publication

18.8 Delays in the publication of land-use statistics including irrigation statistics are most frustrating. By the time the statistics are published, they lose their freshness. Throughout our report, for example, we have been compelled to use statistics which are at least three years old. It is natural that when statistics are prepared after physical verification and have to pass through three intermediaries from the village through the tehsil, to the district and finally through the State to the Ministry of Agriculture, delays are bound to occur. Indeed the volume of work involved in completing the 'Basic Village Form' and 'Village Abstract' is tremendous and the over-worked Patwari cannot do it justice.

18.9 We have given considerable thought to the question as to how the process of statistical compilation can be expedited and have come

to the conclusion that it cannot be done without the aid of computers. The primary statistics should continue to be collected after physical verification by the Patwari. Where the Patwari is over-loaded with work, he should be given an assistant to relieve him of some less important work. He should be given training in the collection and compilation of data in the Basic Village Form and the Village Abstracts. There should be a statistical officer for each district who should carefully supervise and make a sample check of 5 per cent to 10 per cent of the villages to ensure the accuracy of entries in the Basic Village Form. The District Statistical Officer should be a qualified statistician and he should be given sufficient status and staff to get this work done thoroughly and effectively.

18.10 In States where computer facilities are available, a copy of the Village Abstracts should be sent to the State headquarters. In other States where such facilities are not available, the forms should be sent to the nearest computer centre for processing. The States should make arrangements for the computerisation of information supplied in the 'Village Abstract' and for the preparation of abstracts at different levels. The abstracts should be routed back to the districts. This, in our opinion, will not only ensure the accuracy of the statistics but also expedite their availability. Through this process we do not see any reason why general irrigation statistics should not be available within twelve months of the close of the period to which they relate.

Quinquennial Survey of Irrigation

18.11 The land-use statistics as collected at present do not indicate the area irrigated from major, medium and minor works separately. The statistics relating to minor irrigation works suffer from an inadequacy of details. Figures for the areas served by each of the minor irrigation works are not collected. Wells are of different types, some energised and operated by electricity or diesel engines, and others where the lift is done by other devices like a Persian wheel or Rahat. No reliable statistics are being collected for these different types of wells. A large number of seasonal earthen wells are also dug but they do not find an adequate place on the records. Little or no record is kept of the state of maintenance of minor irrigation works. We recommend, therefore, that a quinquennial survey of all irrigation works should be carried out to give complete information on the above points plus such other information referred to in para 18.7 which is not being collected at present.

Irrigation Department's Statistics

18.12 In the whole of India except the four States of the south, namely, Andhra Pradesh, Mysore, Tamil Nadu and Kerala, the Irrigation/Public Works Department collects, compiles and maintains the statistics of the irrigated area under Governmental works. The primary agency employed for the purpose is a junior official known by different names in different States—Canal Patwari, Irrigation Booking Clerk, Irrigation Patwari, Canal Patrol or Amin, etc. The work of this official is supervised by an Overseer, an inspection officer or a Sub-divisional officer. The department collects statistics for different projects and for different crops on all works owned by Government, whether major, medium or minor. The statistics collected at the primary level are consolidated in the Divisional or Circle Offices and sent to the Chief Engineer for publication in the Annual Administration Report of the State Department of Irrigation.

18.13 In the four States of the south, however, as the work of assessment of water rates is done by the Revenue Department, the Irrigation Department is denied the benefit of a function which, we consider, is essentially its own. The collection of statistics as is done in the northern States will help to give the irrigation officers an idea of the performance of irrigation. We recommend, therefore, that the practice relating to the collection, compilation and maintenance of statistics for Government-owned works, as it obtains in the rest of India, should be followed by the southern States.

18.14 All irrigation works are not of equal efficiency. Even within the same category, say in a storage or diversion work, there are differences in performance. We have recommended that the water rates should be based on the quantity and timely supply of water. It follows, therefore, that the rate for less effective irrigation should be lower than for more effective irrigation. We recommend, therefore, that the irrigation works of a State must be divided into well-defined categories on the basis of performance, and entries made in the records to indicate to which category a particular State irrigation work belongs.

18.15 The State Irrigation Departments also prepare progress reports of irrigation schemes under construction which give figures of the potential created and the potential utilised for each major-medium project. The area irrigated by completed minor irrigation works are, we understand, in some cases, not actuals but based on certain assumptions related to the amount of money spent on them. We deprecate this practice and recommend that the figures should be actuals based on facts.

18.16 Our attention has been drawn to certain lacunae in reporting irrigation statistics in progress reports. For instance, no separate entry is made for old irrigated areas which benefit from new irrigation, water conservation, ground water re-charge, drainage, flood control, ground water exploitation and other measures. No allowance is made for depreciation in the capacity of the existing works. We would like these shortcomings to be rectified.

18.17 We have noticed that there are substantial differences in the irrigation statistics as collected by the Revenue/Land Records Departments and the Irrigation/Public Works Department. In Madhya Pradesh, the Irrigation Department's statistics are based on agreements between the cultivator and the Department. The statistics of the Land Records Department are based on the actual survey of irrigated area. This results in different statistics for the same area. Two sets of statistics for the same area are not only confusing but create doubts in the minds of the public as to the accuracy and reliability of both sets of statistics. We have found that canal statistics are being freely questioned. We recommend that the methods followed by the Irrigation/Public Works Department and the Revenue/Land Records Department of the States should be carefully looked into and the anomalies resolved so that the discrepancies are minimised and, if possible, eliminated.

18.18 The proposal made by us for the computerisation of the information contained in the Village Abstracts and a strict supervision by the District Statistical Officers on the collection of data will go a long way towards removing the defects and inaccuracies of the present system of collecting and compiling irrigation statistics.

18.19 We would also like the State Governments to examine the machinery for compiling and publishing irrigation statistics in the Irrigation/Public Works Departments. We are of the opinion that a Statistical Cell should be created in the State Departments of Irrigation which would enable the timely compilation and publication of irrigation statistics. Maharashtra, Madhya Pradesh, Uttar Pradesh, Haryana and Punjab have already set up such Statistical Cells in their Irrigation Departments.

O.P. Gupta	Ajit Prasad Jain
D.V. Reddi	Leslie J. Johnson
K.S.S. Murthy	K.V. Ekambaram

New Delhi, 30th March 1972

CHAPTER XIX

SUMMARY*

Physiography

The sub-continent of India covers an area of 328 million hectares and supports a population of 547 millions. It has a land frontier of 15,200 km. and a coastline of 5,700 km.

19.2 The perennial rivers of the Himalayan region and the rivers of peninsular India constitute the main river systems. The Himalayan rivers are fed by the melting snows and glaciers of the Great Himalayan ranges. They are often uncertain and capricious in their behaviour and sometimes subject to drastic changes of course. In the dry weather, the flow in these rivers is significantly enhanced by water from the melting snows and glaciers. The flow is considerably reduced in the winter, but never to the same extent as in the peninsular rivers. The peninsular rivers originate at much lower altitudes and flow through areas which are geologically more stable, so that they are more predictable in their behaviour. Their flow is characterised by heavy discharges during the monsoons, followed by low discharges during the dry months.

Climate

19.3 The great mountain mass formed by the Himalayas and its spurs on the north, and the ocean on the south are the two major influences affecting the climate of India. The first forms an impenetrable barrier to the influence of cold winds from Central Asia, and gives the sub-continent the element, of the tropical type of climate. The second is the source of cool moisture-laden winds which reach India and give it the elements of the oceanic type of climate.

India has a very great diversity and variety of climate and weather conditions. The climate ranges from continental to oceanic, from extremes of heat to extremes of cold, from extreme aridity and negligible rainfall to excessive humidity and torrential rainfall.

*In this Chapter only the more important aspects have been summarised.

19.4 The south-west monsoon is responsible for 80 per cent or more of the total annual precipitation outside Assam, Bengal, coastal Orissa and parts of the peninsula. In Gujarat, Saurashtra, Kutch and adjoining Rajasthan and Madhya Pradesh, it accounts for more than 90 per cent. The States of Orissa, Bihar, West Bengal, Assam and eastern Madhya Pradesh, the West Coast and the Ghats as also the sub-montane belt which extends from north Bihar to Jammu receive more than 100 cm. of rain during this season. Southern Punjab, north-west India from Veraval in Saurashtra through Delhi to Jammu receive 50 cm. of rain or less. The rainfall decreases rapidly towards the west and on the western border of Rajasthan it is less than 10 cm. The lowest rainfall is in the extreme south-east peninsula where districts such as Kanyakumari and Tirunelveli get less than 2.5 cm. In the rain-shadow of the western Ghats, the rainfall is only 40 to 50 cm. during this season. In some patches, it is 30 cm. or less.

Soils

19.5 The four major soil groups in India are (i) alluvial soils, (ii) black soils (regur), (iii) red soils, and (iv) laterite soils. Of less importance are forest soils, desert soils, saline and alkaline soils. The behaviour of soil under irrigation is of primary importance. The capacity of the soil to take in water and hold it and its effective rooting depths are important criteria for determining irrigability. The depth and frequency of irrigation is a function of soil properties. The greater the water-holding capacity, the greater will be the irrigation depth, and in consequence, the lower the irrigation frequency. From the point of view of drainage, the main criterion is the hydraulic conductivity of the sub-soil or the sub-stratum.

Utilisable Water Resources

19.6 The total utilisable water resources of the country have not been systematically studied or analysed except for the Indus River System. Preliminary studies relating to the Godavari, the Krishna, the Narmada and the Tapi indicate that the entire water resources of these rivers can be utilised. The waters of the Cauvery have already been almost fully utilised.

Of the 493 t. m. cu. m. (400 MAF) of water in the Ganga, it should be possible to utilise about 185 t. m. cu. m. (150 MAF) for irrigation. A higher utilisation is precluded for reasons of topography and the shortage of storage sites so that most of the water will still continue to flow into the Bay of Bengal. There is very little possibility of utilising the waters of the Brahmaputra except through a few medium and minor lift irrigation

schemes in Assam. Nearly 370 t. m. cu. m. (300 MAF) of the Brahmaputra is likely to continue to flow annually into the Bay of Bengal.

The west-flowing rivers of India (excluding the Tapi and the Narmada) are also important sources of water. They carry, on an average, nearly 247 t. m. cu. m. (200 MAF) but due to the narrowness of the coastal plains through which they flow, the possibilities of using these waters for irrigation are very limited. Some water may, however, be diverted eastwards for irrigation.

The Mahanadi and other east-flowing rivers have a sizeable water potential but not all of it can be utilised. About 74 t. m. cu. m. (60 MAF) of these rivers would continue to flow into the Bay of Bengal.

19.7 The utilisable water resources of the country are roughly as indicated below :

1. Narmada, Tapi, Godavari, Krishna, Cauvery and other Southern rivers.	246,700 m. cu. m. (200 MAF)
2. The Indus System	49,300 m. cu. m. (40 MAF)
3. The Ganga System	185,000 m. cu. m. (150 MAF)
4. The Brahmaputra System	12,300 m. cu. m. (10 MAF)
5. The Mahanadi and other east-flowing rivers	123,400 m. cu. m. (100 MAF)
6. West flowing rivers, excluding the Tapi and Narmada	49,300 m. cu. m. (40 MAF)
Total :	666,000 m. cu. m. (540 MAF)

Progress of Irrigation

19.8 On the eve of Partition, the net irrigated area in the Indian sub-continent was about 28.2 million hectares amounting to about one-fourth of the total cultivated area. 54 per cent of the area was irrigated by canals, 23 per cent by wells, 12 per cent by tanks and 11 per cent by other miscellaneous sources. The partition of India brought about sudden and drastic changes. It greatly depleted the irrigation potential of India as shown in the table below :

Country	Net sown area	Net irrigated area	Col. 3 as per cent of Col. 2
1	2	3	4
Undivided India	116.8	28.2	24.1
India	98.5	19.4	19.7
Pakistan	18.3	8.8	48.1

19.9 Since Independence, the gross irrigated area from major, medium and minor works has risen steadily to 28.0 million hectares in 1960–61 and to 33.13 million hectares in 1967–68. A sum of over 30 billion rupees has been spent up to the beginning of the Fourth Plan on irrigation schemes.

Planned Development of Water Resources

19.10 A comprehensive strategy to ensure the success of agriculture should aim at meeting the water requirements of crops through the economic and judicious use of water.

A river basin and, in the case of large rivers, a sub-basin is the natural unit for planning water resources. This planning should be based on an assessment of the surface and sub-surface water resources of the basin, and their utilisation.

19.11 The Commission recommends the following policy for formulating river basin plans, on the basis of the feasibility status of individual projects :

(a) The basin plan should present a comprehensive outline of development possibilities of land and water resources to meet the anticipated regional and local needs.

(b) The plan should,

  (i) indicate a broad frame-work of various engineering works to be taken up in the basin giving reasons for their choice from the alternatives considered and inter-relationship between those works;

  (ii) establish priorities in respect of water use for various purposes;

  (iii) indicate *inter se* priority of projects; and

  (iv) indicate the need for earmarking water for any specific future purposes.

(c) The basin plan should be periodically reviewed and revised to take into account changes in storage capacity and the extent and pattern of water use.

19.12 Domestic requirements should have the highest priority in the allocation of water, followed by industry and then by irrigation. As between irrigation and power generation, the Commission recommends that priority be given to irrigation.

19.13 The Commission recommends that instead of the Irrigation Department determining the cropping pattern in consultation with the

Agriculture Department, as is done at present, the latter Department should determine the pattern in consultation with the Irrigation Department.

While designing future canals, the results of research on soil-plant-water relationships, the contribution of rainfall in the growth period of crops and the interaction of other inputs like fertilizers, should be taken into account, and duties, deltas and water allowances fixed accordingly.

19.14 There is large scope for the conjunctive use of surface and sub-surface water, particularly in the Indo-Gangetic Plain, the coastal areas of Orissa and Andhra Pradesh, the Cauvery Delta and part of the Narmada basin. It can also be applied to a lesser extent elsewhere in the country, where canal supplies can be supplemented by open wells or tubewells.

The Commission recommends that areas where conjunctive use is feasible, should be identified, particularly in the commands of existing canal systems.

19.15 There should be a number of fully investigated schemes kept ready for choice, so that financial resources may not get deployed on relatively uneconomic schemes. The quality of investigations should not be sacrificed to speed up project formulation. The investigation of irrigation projects and their ayacut development should be undertaken simultaneously. Also, studies of soil conservation measures, particularly for the more critical areas in the catchment should be taken in hand at the same time.

Policies and Considerations in Irrigation

19.16 For judicious use of limited irrigation supplies, it is important to determine critical periods during which deficiency of moisture in the soil can seriously reduce the yield of crops. Irrigation systems should provide water not only in the required quantity but at the required time.

19.17 Rice requires much more water than other cereals, but its productivity per unit of water is much lower than that of others. The Commission, therefore, suggests that the need for adequate support from rainfall should be kept in view while planning for rice production. It further recommends that a second rice crop, particularly in the non-rainy season, should be grown in an area only if the irrigation supplies cannot be put to better use.

19.18 Broadly, the goals for irrigation policy may be classified under three heads viz.,

(i) maximum production per unit of area, as in the Brahmaputra Valley, Kerala and the Indo-Gangetic Plain;
(ii) maximum production per unit of water, as in regions of medium and low rainfall, in which about 70 per cent of the cultivated area of India lies; and
(iii) maximum area served, as in drought affected areas.

19.19 In the southern States, the heavier black cotton soils are generally located in the valleys, and the lighter red soils higher up. Growing paddy in the higher light soils leads to a comparatively larger consumption of water and the problem of waterlogging. Paddy should, therefore, be localised, as far as practicable, on the heavier soils at lower levels and the lighter red soils reserved for light irrigated crops.

19.20 Lining must be resorted to where water resources are inadequate and particularly where the percolated water cannot be retrieved or, when retrieved, is unfit for use. The Commission recommends that in all future projects, the main canals and branches should, in general, be lined and the lining of distributaries undertaken as and when resources become available. As an alternative to lining small water courses, pipelines may be worth considering.

19.21 There are many areas in the country where the use of sprinkler or drip irrigation would be more useful. There is, however, need for research, experimentation and demonstration to identify the areas, conditions and crops which are most suitable for this mode of irrigation.

19.22 Farmers should be encouraged to lift water for irrigating areas in canal commands which cannot be served by flow. Drain water should be utilised for irrigation in an authorised manner and the farmers be charged lift irrigation rates for it.

Some major rivers, particularly the Ganga and the Brahmaputra offer considerable scope for Floating Pump Irrigation Schemes. The Commission recommends that these possibilities should be fully explored in Assam, Bihar, Uttar Pradesh and West Bengal and on some major rivers in other States.

19.23 At present, irrigation projects are designed on the basis of a 75 per cent dependability. Availability can be improved by providing a carry-over capacity in storage reservoirs at an additional cost. The economics of this device needs consideration. The more precious the water in an area, as in drought areas, the greater is the justification for providing a carry-over.

Ayacut Development

19.24 Systematic ayacut development in India has taken shape because of delay in the utilisation of water in some command areas. Its aim is to ensure rapid utilisation of the irrigation potential of new irrigation projects. This calls for a series of co-ordinated measures. The command areas of projects should be fixed in advance. Soil surveys should be undertaken, and only those crops which are suited to local soil and climatic conditions should be encouraged. Scattered holdings should be consolidated. Farmers' fields should be properly levelled, shaped and kept ready with field channels, so that the water can be utilised without delay. The supply of inputs needs to be streamlined, and research and extension efforts geared to support a forward-looking agriculture. Attention should also be paid to the need for additional roads, markets and storage and other infrastructure facilities.

The Commission recommends that a comprehensive plan of ayacut development should be prepared for every major and medium irrigation project, simultaneously with the preparation of a plan for the project.

The Commission is of the opinion that a special administrative agency for the co-ordinated and expeditious development of command areas under medium and major projects is very necessary. No separate cadres should be created for the ayacut development programme and the relevant departments of the State Government, such as Irrigation, Agriculture, Co-operation, etc. should continue to discharge their respective functions within the ayacut under the normal departmental control. The co-ordinating agency for the ayacut could, however, set out specific tasks for various departments and institutions, co-ordinate their activities and ensure implementation of the agreed programme. Each irrigation project deserves a separate ayacut development agency.

19.25 The States are unanimous that the absence of field channels has been a major reason for serious lags in the utilisation of irrigation potentials. In 1966, Mysore State took upon itself the responsibility of excavating field channels. This brought about a spectacular improvement in the utilisation of the irrigation potential. Andhra Pradesh took action on similar lines in the Nagarjunasagar project and this also had a salutary effect.

19.26 We have made recommendations for land-levelling and land-shaping and also their financing from institutional sources.

19.27 We have also recommended that research should be conducted in command areas of projects to encourage the farmers to adopt improved

irrigation practices and crop patterns with confidence. Demonstration plots, training programmes and the use of television for educating the farmers have been recommended.

19.28 During the formulation of the Fourth Five-Year Plan, the Government of India felt that the development of regulated markets, all-weather roads and storages had lagged behind, because the State Governments could not find the funds for it. It led to the acceptance of the Area Development Programme as a centrally sponsored scheme, and was to be executed through the State Governments. Before any command area became eligible for inclusion in the programme, the State Governments concerned have to provide funds for all other services and works which form part of the plan. The Commission hopes that the tempo of these activities will gain momentum and have a larger coverage.

Drought Affected Areas

19.29 The India Meteorological Department has defined drought as a situation occurring in any area when the annual rainfall is less than 75 per cent of the normal. Areas where drought has occurred in 20 per cent of the years examined, are considered 'drought areas', and where it has occurred in more than 40 per cent of years, as 'chronic drought areas'. A persisting adverse water balance has also been found to be a characteristic of the drought areas.

19.30 On the basis of the annual and south-west monsoon rainfall data from 1901 to 1960 for about 500 stations, drought and chronic drought areas have been identified as follows :

(a) Drought areas (20 per cent probability of rainfall departures of more than (—) 25 per cent from the normal).

(1) Gujarat, Rajasthan and adjoining parts of Punjab, Haryana, west Uttar Pradesh and west Madhya Pradesh.
(2) Madhya Maharashtra, interior Mysore, Rayalaseema, southern Telangana and parts of Tamil Nadu.
(3) A small portion of north-western Bihar and adjoining east Uttar Pradesh.
(4) A small portion of north-eastern Bihar and adjoining portion of West Bengal.

(b) Chronically drought affected areas (40 per cent probability of rainfall departure of more than (—) 25 per cent).	Western parts of Rajasthan and Kutch.

As the chronically drought areas and drought areas are part of the same meteorological phenomenon and the difference between the two is one of degree, for our purposes no distinction has been made between the two.

19.31 We have accepted the taluk as a unit for identifying and planning for drought areas. From the list of the taluks furnished by the State Governments, the Commission has excluded (i) those which lie outside the drought zone; (ii) those where 30 per cent or more of the cropped area is irrigated; and (iii) those which comprise only a small portion of the districts with an adequate rainfall or irrigation. After these adjustments, most of the drought areas which need special attention lie in the States of Mysore, Andhra Pradesh, Gujarat, Rajasthan, Maharashtra and Tamil Nadu. The hard-core areas of drought comprise about 16 per cent of the total geographical area of the country and account for over 11 per cent of its population.

At present, about 13 per cent of the cropped area of the drought affected region is irrigated. This is likely to rise to about 19 per cent when the schemes under execution are completed. In the drought areas of Madhya Pradesh, Mysore, Maharashtra, and Gujarat, where the present level of irrigation is lower than 13 per cent, the position may be worse. The extent of the area irrigated in the drought districts is not likely to go above 25 per cent of the cropped area when all the works proposed by the States for these areas are completed.

The needs of the drought areas will not be adequately met by any *minimum* programme of irrigation. What is needed is a *maximum* programme, because even if such a programme is implemented, drought areas will lag behind. In drought areas only 25 per cent of the cropped area will come under irrigation, as against the 50 per cent for the country as a whole.

The Commission recommends that high priority should be given to irrigation works in drought areas.

19.32 If rigorous tests of productivity are applied, it may not be possible to take up as many new schemes as is desirable for drought areas. The likely expenditure on famine relief also needs to be kept in mind because the introduction of irrigation would reduce, if not eliminate, such expenditure.

Only a few States, like Gujarat and Maharashtra have given thought to the special needs of drought areas in determining criteria for financing irrigation projects. The Gujarat Government has relaxed the benefit-cost ratio in respect of major and medium schemes in drought and other backward regions up to unity. The Maharashtra Government allows the same relaxation but only in respect of irrigation schemes costing less than Rs. 30 million. Both these Governments have fixed more liberal yardsticks in respect of minor works, like storage tanks, percolation tanks, check dams, etc. The Gujarat Government has removed all cost restrictions on medium or minor irrigation schemes in scarcity areas, under certain conditions. The Commission supports a liberal policy for irrigation works in drought areas and recommends that the benefit-cost ratio of major and medium works in those areas may be relaxed up to unity. The States should be provided with loans at the concessional rate of half the normal rate to facilitate the construction of irrigation works in the drought areas.

Improvements to Existing Irrigation Works

19.33 Many of the irrigation systems in the country date back to the 19th century or earlier, and need remodelling. Among such systems are the Eastern and Western Yamuna Canals, the Cauvery Delta System, Upper Ganga Canal and the Godavari Delta System. The usefulness of these systems is limited by structural handicaps, such as out-moded head-works, the absence of silt excluding devices and unsatisfactory cross drainge. Faulty irrigation practices and poor drainage add to these handicaps. As a result, the systems cannot meet the exacting demands of water for the new high-yielding varieties of crops.

Irrigation from wells of all kinds forms 30 per cent of the total irrigation in the country. Many of these wells and tubewells lie within the command areas of canal systems.

The Commission recommends that inadequacies in run-of-the-river systems should be met by the increased use of ground water, by the construction of storage reservoirs and by supplementing supplies by transferring water from an adjacent basin. Farmers should be encouraged by providing them financial assistance, technical guidance and electricity, to sink wells or tubewells so as to make up any inadequacies in supply from canals and to extend irrigation.

Other measures recommended to mitigate the effect of inadequacies are the lining of canals, the control of drainage, the provision of regulators and escapes, the substitution of weirs by barrages and the improvement of headworks.

The hydraulic performance of some systems has been reduced by the

addition of temporary outlets, by changes in canal sections due to silt, erosion, cross-bunding and the cutting of banks. This calls for remodelling. Periodic examination of each system once in twenty or thirty years should be done to make systems up to date. The remodelling project undertaken in the Cauvery Delta illustrates the big gains accruing from planned remodelling. Remodelling schemes should include, inter alia, (i) measures for working the system with greater efficiency and minimum loss of water; (ii) measures to supplement supplies by pumping water from neighbouring rivers or from sub-soil reservoirs and by transferring water from adjacent basins; (iii) changes in cropping patterns; and (iv) measures to enlarge areas under irrigation and to increase its intensity.

Existing methods of conveying water from the outlet, and field-to-field irrigation of rice are causes of a heavy waste of water. The Commission recommends that effective steps should be taken gradually to replace field-to-field irrigation of rice by the system of field channels. There should also be separate drains serving individual fields.

The Future Perspective

19.34 A third of the country is prone to drought, which makes for low yields. Improved dry-farming practices can improve yields, but the results can at best be a fraction of those from irrigated areas. The growing disparity between irrigated and dry regions can be reduced only if vigorous steps are taken to improve irrigation facilities in the dry zones. The perspective of development is thus not confined to the limited aim of increasing agricultural production, but has been extended to include the broader objectives of removing social and regional disparities.

19.35 The provisional totals of the 1971 census reveal that the total population of India on 1 April, 1971 was 547 millions. The growth rate of 24.66 for the decade 1961–70 closely tallied with the projected growth rate of 24.6 for the quinquennium 1966–70.

The demographers have worked out firm population projections only up to the year 1985. The Commission proceeds on the assumption that the expected population growth rate of 14.5 per thousand per annum, attained during the quinquennium 1981–85, will be maintained in the subsequent 15 years. On this basis, India's population in the year 2000 A.D. would work out to around 900 millions, an increase of 65 per cent over the 1971 population.

The food and fibre requirements at the end of the century will, however, increase by about 100 per cent because of the likely rise in living standards. The country must, at the very least, produce twice its present output of food and fibre. This increase is possible if more areas are brought under irrigation.

19.36 Scope for extension of agriculture to new areas is almost exhausted, and future increases in yield must be secured from intensive and double cropping.

An analysis of yields and irrigated areas under principal crops—rice, wheat, pulses, oilseeds and cotton—made by us lead to the inescapable conclusion that the crop yields are high in States which have a high percentage of irrigated area under the crop, and low where the irrigated percentage is less.

We are of opinion that significant results in increasing yields of these crops can be achieved if proper attention is given to irrigation, particularly in the States mentioned below :

Rice	Bihar	West Bengal	Uttar Pradesh	Orissa
Wheat	Uttar Pradesh	Madhya Pradesh	Rajasthan	Bihar 4
Pulses	Madhya Pradesh	Rajasthan	Maharashtra	Bihar
Oilseeds	Uttar Pradesh	Gujarat	Andhra Pradesh	Madhya Pradesh
Cotton	Maharashtra	Gujarat	Mysore	Madhya Pradesh

19.37 Many States have not furnished a reasonably accurate assessment of future possibilities of irrigation development by surface and ground waters. In some cases it appears that the figures were based on a rough assessment.

As the inter-State disputes over the waters of the Krishna, the Godavari and the Narmada are pending before inter-State water tribunals, the total irrigation potential of Andhra Pradesh, Mysore, Maharashtra, Madhya Pradesh, Orissa and Gujarat cannot be worked before the tribunals allocate water to the various States.

In some cases the projects proposed by two or more States in the same river valley are mutually exclusive. Which of these projects would be sanctioned ultimately and in what form, can be determined only after the completion of river basin plans and agreement among the States concerned. The total irrigation potential suggested by such States is liable to be reduced.

A great deal of work has been done in the past few years to assess the ground water potential, but a complete assessment for the whole country has not so far been carried out. At best, the estimates of ground water potential are based on certain assumptions which may or may not turn out to be correct.

Of over 500 medium irrigation schemes taken up during the last

20 years, more than three-fifths have been completed. With better planning and co-ordination, it should be possible to complete the investigation of the remaining schemes in the next 5–7 years. If necessary funds are allocated, it should not be difficult for the States to complete all medium works in about 15 years. Minor works should be completed within a period of 10 years.

Of the total irrigated area of 40.5 million hectares, the perennial flows of the Himalayas account only for about four million hectares. Tubewells account for another 2.4 million hectares. The rest of the area depends for its water supply on storages and river diversion schemes, and shallow aquifers.

More than 90 per cent of the river flow occurs in the monsoon months of June to September. It is imperative that storages should be built to impound monsoon flows for utilising that water for irrigation in winter and summer. Big storages have big catchment areas, and variations in rainfall do not affect them to the same extent as they do small tanks. These reservoirs provide assured irrigation.

19.38 The Commission estimates the total irrigation potential of the country, both from surface and ground water resources, including 20 million hectares of the Godavari, the Krishna and the Narmada, as of the order of 81 million hectares. This would provide irrigation facilities to about 50 per cent of the total cropped area.

If this potential is developed by the turn of the century it would double the production of food and fibre in the country, including increases in yield effected by improved varieties of seeds, fertilizers, pesticides etc. This increase would not only ensure self-sufficiency in 2000 A.D. but also lay a sound foundation for higher production in subsequent years.

19.39 The cost of the major and medium irrigation projects sanctioned during the last few years varies from Rs. 1500 to Rs. 3000 per hectare and averages around Rs. 2000. The future projects will be more expensive than the present or those now under way, because of difficult locations and complex technology involved. It may, therefore, be reasonable to assume that the future schemes, on an average, will cost Rs. 3000 per hectare at current prices. On a rough basis, the cost of future development may work out to about Rs. 100 billion.

19.40 The Ganga-Cauvery link will operate as a grid to make up periodical shortages in the Son, Narmada, Godavari, Krishna and Cauvery systems. This gigantic project should be investigated.

19.41 We are of the opinion that proper attention should be given

to maintain the ecological balance in the planning of major irrigation works.

Economics and Financing of Irrigation Works

19.42 The Commission supports the adoption of the benefit-cost ratio criterion in sanctioning projects. It, however, recommends that the financial return of the projects should also be examined. The present practice of accepting projects only if the benefit-cost ratio is more than 1.5 is a prudent precaution. The Commission, however, recommends that this rule should be relaxed in favour of irrigation projects in the drought affected areas where a lower limit of unity may be accepted. In working out the benefit-cost ratio, the investment on ayacut development comprising land-levelling and construction of field channels and field drains should also be taken into account. The investment which may be necessary for soil conservation measures in the catchment area need not be considered.

19.43 The Commission wishes to emphasise that once a scheme is taken up for implementation, it must be constructed at an optimum pace determined by technical considerations and the necessary funds must be provided for it. Where an irrigation scheme is too large for proper financing from the State's own plan resources, the State should negotiate with the Union Government for special financial arrangements for the scheme.

19.44 Irrigation works in India were making a net annual contribution to the exchequer of over Rs. 10 million, at the time of Independence. There was an annual loss of Rs. 566 million in 1967–68. The Commission is of the view that irrigation works in a State should give an annual income at least equal to the annual cost of operation. No part of the burden for providing irrigation should fall on the general tax-payer.

19.45 Essentially, the value of irrigation is the benefit it gives to the farmer. From the irrigator's point of view, therefore, the water rate should be related to the benefit which irrigation confers rather than to the cost of an irrigation project. There can be no precise formula for the fixation of water rates, which remains a matter for administrative decision. As a guideline, the Commission recommends the following principles :

(i) Water rates should be levied on a 'crop basis', except in the case of irrigation from tubewells;

(ii) The rate should be related to the gross income from the crop and not to the cost of the project. It should range between 5 per cent and 12 per cent of gross income, the upper limit being applicable to cash crops;
(iii) The rates should be within the paying capacity of irrigators and aim at ensuring full utilisation of available supplies;
(iv) As between regions with a similar class of supply, there should be the minimum disparity, if any, in the rates charged;
(v) For fixing rates, irrigation should be divided into A, B and C categories on the basis of the quantity and timeliness of supplies of water. Lower rates may be fixed where, on account of good rainfall, the demand for irrigation water is less or where the supply is inadequate and uncertain;
(vi) The general level of rates in a State should be such that, taken as a whole, the irrigation schemes do not impose any burden on the general revenues.

Irrigators in drought affected areas derive larger benefits from irrigation than those in other areas. The Commission is of the opinion that farmers in these areas should be charged the normal irrigation rate.

In canal commands, a lower rate should be charged for lift irrigation in view of the extra effort or expenditure involved in lifting water and the economy in its use.

19.46 Tubewell water is charged on the basis of the quantity of water supplied at the tubewell in some States, and in others on the basis of the electricity consumed. The Commission is of the view that the former is more equitable.

19.47 The Commission recommends that water rates should be reviewed and revised by all the States in the fourth year of every Plan.

19.48 In order to remove difficulties experienced in enforcing the existing laws for betterment levy, the Commission recommends that these laws should be amended so that half the capital cost of the irrigation projects is recovered from the beneficiaries.

Administration and Organisation

19.49 The massive programme for the development of water resources calls for a streamlining of the procedures and agencies dealing with irrigation both at the Centre and in the States. Our recommendations in this connection are :

19.50 A Directorate of Hydrology should be set up under a Director-General. The functions of the Directorate will be to collect hydrological data, standardise procedures and publish the data.

19.51 Prospecting and mapping of ground water has been the responsibility of the GSI. Recently a decision has been taken to transfer the division doing this work from the GSI to the CG&WB. The Commission recommends that the decision may be reviewed and the GSI allowed to continue to do this work.

The CG&WB which is at present under the Ministry of Agriculture, should be transferred to the Ministry of I&P.

19.52 Each river basin has its peculiar characteristics and would need a plan of its own. To formulate twenty major river basin plans will be too heavy a task for a single commission. We have recommended that seven River Basin Commissions should be set up for the whole country. To begin with, the work may be entrusted to four Commissions.

Each Commission would consist of four whole-time members nominated by the Union Government; two engineers, an agricultural economist and an agronomist. The Chairman of the Commission will be nominated by the Union Government. Each State Government concerned with the basin shall be represented by a Chief Engineer. The small States and Union Territories may be grouped and given representation by rotation.

The basin plans prepared by the Commission will be sent to the States for opinion, and, thereafter, the plans with the views of the States and the comments of the Commission, if any, will be submitted to the National Water Resources Council. The plans will then be forwarded to the States and the Union Government.

19.53 The Commission recommends the setting up of a high level authority 'The National Water Resources Council' to take policy decisions relating to the conservation, utilisation and inter-basin transfers of water; to lay down priorities for the use of water; to keep a continuous watch on the working of the River Basins Commissions and problems of inter-State rivers, and to ensure that the formulation and execution of irrigation projects is in accordance with the highest national interest.

The Prime Minister of India should be the Chairman of the Council and the Union Minister for Irrigation & Power, its Vice Chairman. The Ministries of Finance, Agriculture, Community Development, Planning, Health, Industry and Tourism should be represented on it through their Ministers.

Major States should be represented on the Council either by the

Chief Ministers or by the Irrigation Ministers. The smaller States and the Union Territories would have group representations by rotation.

Two eminent irrigation engineers and the Chairman, CW&PC should also be Members of the Council. The CW&PC will act as the Secretariat of the Water Resources Council.

The National Water Resources Council and the River Basins Commissions should be created by an Act of Parliament.

19.54 The Chairman of the CW&PC should be ex-officio Special Secretary in the Ministry of Irrigation & Power.

19.55 The work of exploitation of ground water in the State should be entrusted to two divisions; one under the Irrigation Department dealing with planning, operation and maintenance of heavy duty State tubewells, and the other under the State Agriculture Department dealing with drilling, boring of private wells and shallow tubewells.

19.56 The Governments of the southern States and Maharashtra should consider proposal to make their Irrigation Departments responsible for the management of water from the source to the field as practised in the northern States.

19.57 The present system of keeping the Secretariat separate from the Department is sound.

One of the Chief Engineers should be appointed as an Additional or Joint Secretary in the State Irrigation Department.

19.58 The Commission is of the opinion that in the appointment of the Secretary, Union Ministry of I&P and Secretaries to the State Irrigation Departments, technocrats should be treated at par with generalists.

19.59 Early steps may be taken to set up the Indian Service of Engineers.

Waterlogging, Drainage and Floods

19.60 Large tracts in the Indo-Gangetic plain suffer from waterlogging. The State of Punjab before its second re-organisation, had the largest affected area. Signs of waterlogging also appeared in Maharashtra in the commands of the Deccan Canals. Even in recent projects like the Chambal in Rajasthan and Madhya Pradesh waterlogging has become a problem. As irrigation is extended and developed, necessary precautions should be undertaken in advance to avoid waterlogging.

The Presidency of Bombay, as it was then known, was the first to set up an irrigation research division in 1916. This division made valuable studies and Maharashtra has implemented a number of drainage schemes.

19.61 Other States have also constructed drainage works and other schemes like flood embankments, pumping out drainage water, and seepage drains. However, the Commission is of opinion that a more vigorous and planned action on the lines of what has been done in Punjab, is called for in many other States.

The Commission feels concerned about dangers of serious waterlogging in the command areas of the Gandak and Kosi Projects. The high water table, heavy rainfall, perennial irrigation and the flat nature of the terrain are conditions that can create serious problems in these areas. The Commission recommends that the dangers of waterlogging in the Gandak and Kosi projects should be vigorously dealt with from now on.

The Commission hopes that the States will continue to take steps to improve drainage in their irrigated areas. The drains should be excavated to adequate sections, and bad curves should be eased.

The Commission has drawn attention to the need for examining the waterways at bridges, on roads and railway embankments, and cross drainage structures across the canals and waterways across drains.

19.62 The Commission has not been specifically asked to examine the problem of floods. But irrigation cannot be introduced in areas prone to flooding unless they are freed from it. For instance, the extension of irrigation to Purnea and Saharsa districts would not have been feasible but for the flood control works built on the Kosi river.

Floods cause heavy damage to numerous irrigation works and irrigated areas. The sudden floods in the Ganga in 1970 led to heavy silting up of the Upper Ganga Canal which resulted in the closure of the canal for nearly nine weeks during critical parts of the kharif season.

Complete protection from floods can seldom be achieved, even if it were technically feasible. Works for cent per cent protection from floods may not be economically justifiable. Most flood control works aim at minimising the flood damage and protecting the maximum area. Steps should also be taken for flood forecasting to reduce the loss of life and property.

Sedimentation of Reservoirs

19.63 Recently, studies of selected reservoirs to assess the sediment load carried by rivers, and the rate at which silt is deposited have been carried out by the Soil Conservation Directorate of the CW&PC, who

have collected data for 22 reservoirs. In the Tungabhadra reservoir against the assumed siltation rate of 42,861 cu. m. per hundred sq. km. of catchment, the observed rate is 181,927. At this rate, its dead storage will be filled in 22 years, and the live storage in 74 years. In all reservoirs, the observed rate of siltation is very much higher than the rate initially assumed.

Soil conservation is the normal method of protecting the water-shed. It includes such measures as afforestation, pasture development, protection of river fringes, road-sides and the shore-lines of reservoirs, and the control of forest fires.

For an effective soil conservation programme, rivers and streams which carry a heavy silt load should be identified. The next step should be to locate the sources and assessment of sediment. This entails a systematic study of silt loads and discharges at selected observation stations. We have recommended that new observation stations on all important projects should be set up early.

A centrally sponsored scheme now covers 21 major projects for soil conservation. The Commission recommends that the States should make an early assessment of the erosion problem in the catchment areas of reservoirs not covered by the central scheme. Soil conservation should be taken up urgently in the more vulnerable areas.

The Commission recommends that the problem of soil conservation in all major projects should be completed in the next 20 years. In projects where the problem is acute, it should be completed within ten years.

19.64 A special problem, which deserves consideration, is the silting of canals, as has been observed in the Kosi irrigation system. Such silting affects the functioning of the irrigation system. The Commission, therefore, recommends that the silt problem of the Eastern Kosi Canal should receive urgent attention.

Inter-State Water Disputes

19.65 At present, the riparian States in a river valley are free to reach agreement among themselves for sharing the river flows in the valley. Should no agreement be reached, the issues in dispute can be referred by the Union Government to a tribunal on a request made by all or any of the States concerned. Although resort to a tribunal may occasionally be necessary in inter-State water disputes, adjudication is less satisfactory than negotiation.

Joint commissions, such as the European Commission for the Danube, the International Water and Boundary Commission set up by Mexico and the United States and the Niger River Commission and others

have provided useful forum to facilitate international agreements between riparian States. The functions of these commissions include the investigation of the potentialities of a basin, the collection and collation of technical and other data and the formulation of schemes which provide the basis for eventual agreement. A body of this nature creates a climate of negotiation. It helps to define and limit the major issues in dispute. The Commission recommends that the machinery of River Basin Commissions should be used to marshall facts and to clarify issues involved in inter-State disputes.

In the past, the Union Government has played the role of mediator in settling inter-State water disputes. In some cases, it set up committees to assist the contending riparian States to reach an agreement. The Union Government provides substantial funds for plan projects of the States. Since an early settlement of inter-State disputes is important in nation's interest, the Union Government should step in when necessary. It can suggest alternative schemes and can expedite agreements by providing loans and grants or other forms of assistance to balance the scales.

We are of opinion that the Union Government should assume the same active and beneficial role in the settlement of inter-State water disputes as the World Bank did in bringing about the Indo-Pakistan Treaty in the Indus Water Dispute.

Irrigation Acts and Codes

19.66 There are different Irrigation Acts and Codes which regulate irrigation in the States. The Acts vary because of the differences in irrigation practices in different parts of the country. These practices are influenced by such factors, as the incidence of rainfall, soil characteristics, topographic features and the agricultural practices.

In most States there exist a multiplicity of laws covering various aspects of irrigation management and administration. This accounts for multiple lines of authority. The diversification of control diffuses responsibility.

After the reorganisation of States in 1957 irrigation works in certain areas of the same State continue to be administered by the laws of their parent States prior to reorganisation. The Commission recommends that the irrigation laws in each State should be consolidated into a single statute. Within the State the statute should apply uniformly to all regions.

19.67 The existing Irrigation Acts do not define the ownership of sub-surface or ground water. In view of the vital importance of ground

water for agriculture, it is essential to extend control of Government over it to provide control and regulation. The Commission recommends that State Governments should assume legal power to regulate deep aquifers. However, ground water up to a certain depth, say 30 m, in alluvial plains, being voluminous, may be exempted. The Union Government has prepared and circulated a model bill for this purpose.

19.68 The Commission recommends that the law relating to water courses and field channels should make provision for : (i) construction of water courses at Government's cost and their maintenance by the beneficiaries; (ii) construction and maintenance of field channels by the beneficiaries; (iii) on failure to construct or maintain a water course and/or field channel, the State's right to construct and maintain such works and recover the cost from the beneficiaries; (iv) the State's power to construct field channels *suo moto* or on a request made by a majority of irrigators holding more than 50 per cent of land to be benefited; (v) to enact laws on the lines of the Northern India Canal and Drainage Act as applicable to Punjab for the purpose of acquiring land for water courses and field channels; and (vi) for recovery of compensation for land acquired for field channels from the beneficiaries.

19.69 Experience of entrusting certain functions of irrigation administration to the Panchayati Raj institutions and irrigators' cooperatives has not proved satisfactory. The Commission is of opinion that some sort of body composed of irrigators has to be created to share responsibility. The Commission recommends that State Governments should examine the nature of organisations or societies of irrigators to be set up.

Research, Education and Training

19.70 Research in hydraulics and construction material can play an important role in effecting economies and improving quality in the massive programme of construction ahead of us.

The use of standardised precast members in various structures not only reduces the cost but also improves the quality and speed of construction. We are of opinion that research stations should work in closer collaboration with the design centres to promote standardisation.

Local materials should preferably be used to cut down the cost of transport. If suitable local materials are not available, research should be done to improve their quality.

Research activities would need the support of well-equipped libraries, and documentation. The Commission recommends that the library

maintained by the CBI&P/CW&PC should be provided with a proper building and modern equipment. A systematic extension of library facilities to different regions for research and designing is called for.

A significant portion of the literature on irrigation originates from non-English speaking countries such as the USSR and Japan. Translation facilities in English and Indian languages should be provided at CBI&P/CW&PC library.

19.71 Irrigation engineers should acquire a basic knowledge of agronomy. The education and training of irrigation engineers should include a basic course in agronomy.

Irrigation Statistics

19.72 Delay in the publication of land use statistics which include irrigation statistics, is frustrating. The Commission has been compelled to use statistics which are at least three years old.

The Commission recommends: (i) computerisation of irrigation and agricultural statistics at the State headquarters, (ii) training of patwaris, (iii) strengthening of statistical set-up in districts, (iv) preparation of statistical extracts for each village, each district and each State with the aid of computers, and (v) routing back abstracts to appropriate levels of administration.

The Commission hopes that this process will ensure that the statistics are available within twelve months of the close of the relevant period.

APPENDIX 4.1

Projects costing over Rs. 10 million completed during pre-Independence period

State/Name of the Project/Year of completion	Type (Storage or Diversion)	Estimated cost (Rs. million)	Ultimate Benefit ('000 hectares)
1	2	3	4
Andhra Pradesh			
1. Kurnool-Cudappah Canal (1870)	Diversion	76.5	39.51
2. Godavari Delta System (1890)	,,	29.6	449.64
3. Penner river and Canal system (1894)	,,	70.7	74.34
4. Krishna Delta System (1898)	,,	74.1	442.37
5. Nizamsagar (1930)	Storage	39.2	111.29
Bihar			
6. Sone Canals (1875)	Diversion	26.8	347.23
Haryana			
7. Western Yamuna Canal (Ex. Yamuna at Tajewala—1886)	,,	20.2	411.95
8. Western Yamuna Canal (Extension—1892)	,,	15.9	48.94
Madhya Pradesh			
9. Tandula Reservoir (1923)	Storage	12.0	66.76
10. Mahanadi Canal and Murrum-silli Reservoir (1923)	,,	15.7	84.46
Maharashtra			
11. Godavari Canal (Nandur Madhmeshwar Weir—1916)	Storage	10.7	32.15
12. Pravara river works (Bhandardara) (1926) (Wilson dam and Ozat Weir)	,,	16.2	23.07
13. Nira Left Bank Canal and Shetpal Tank (1927)	,,	11.7	47.54
14. Nira Right Bank Canal (Bhatgar Lloyd Dam) (1927)	,,	60.2	35.19
Mysore			
15. Krishnarajasagar Dam and Visveswaraya Canal (1930)	,,	45.0	48.56
Orissa			
16. Orissa Canal (1895)	Diversion	27.2	111.86
17. Rushikulya System (1901)	Storage	12.2	2.79

Appendix 4.1—*Contd.*

(1)	(2)	(3)	(4)
Punjab			
18. Upper Bari Doab Canal (1879)	Diversion	23.6	335.17
19. Sirhind Canal (1887)	,,	45.1	600.17
20. Eastern Canal (1933)	,,	25.8	141.35
Rajasthan			
21. Gang Canal (1928)	,,	33.2	303.52
Tamil Nadu			
22. Periyar System (1897)	Storage	10.8	57.70
23. Cauvery Mettur Project (1934)	,,	66.2	134.00
Uttar Pradesh			
24. Upper Ganga Canal (1854)	Diversion	47.6	699.38
25. Agra Canal (1873)	,,	13.3	138.36
26. Lower Ganga Canal (1878)	,,	45.9	527.95
27. Betwa Canal (1886)	,,	14.0	98.70
28. Ken Canal (1915)	,,	30.3	75.26
29. Garai & Ghaggar Canal (1917)	Storage	16.7	39.30
30. Sarda Canal (1926)	Diversion	151.7	612.47
West Bengal			
31. Damodar Canal Project	,,	12.4	72.85

APPENDIX 4.2

Major Irrigation Projects taken up during the Plan periods

State/Name of the Project/Year of completion	Type (Storage or Diversion)	Estimated cost (Rs. million)	Ultimate Benefit (000 hectares)
1	2	3	4
Andhra Pradesh			
1. Tungabhadra Low-level Canal (1957)	Storage	134.5	60.25
2. Improvement to K.C. Canal and Sunkesula anicut (1962)	Diversion	76.8	122.22
3. Tungabhadra High-level Canal Stage I (1971)	,,	190.0	48.21
4. Kadam Project*	Storage	83.9	34.40
5. Nagarjunasagar Project	,,	1,649.0	833.28
6. Pochampad Project*	,,	401.0	230.68
7. Tungabhadra High-level Canal Stage II*	Diversion	112.0	55.62
Bihar			
8. Chandan Reservoir (1963)	Storage	104.2	70.38
9. Kosi Project (Barrage) (1963)	Diversion	553.3	570.00
10. Sone Barrage (1965)	,,	183.2	124.00
11. Badua Irrigation Project (1966)	Storage	66.0	42.49
12. Sone High-level Canal*	Diversion	88.4	102.00
13. Rajpur Canal	,,	97.2	161.00
14. Western Kosi Canal System	,,	196.9	325.00
15. *Gandak Project*			
(a) Bihar portion	,,	1,081.8	1.151.00
(b) U.P. portion	,,	465.1	—
Gujarat			
16. Shetrunji (Palitana) (1966)	Storage	69.6	34.80
17. Banas (Dantiwada) Project (1969)	,,	108.8	44.52
18. Hathmati Reservoir (1969)	,,	54.5	37.60
19. Mahi Stage I*	Diversion	245.7	186.16
20. Mahi Stage II (Kadana)*	Storage	210.0	16.55 Direct 270.00 Indirect
21. Kakrapar*	Diversion	180.5	227.54
22. Ukai Project*	Storage	1,044.0	152.40 Direct 227.43
23. Narmada (Broach) Irrigation Project*	,,	1,097.0	403.69
Haryana			
24. Remodelling Western Yamuna Canal	Diversion	95.0	264.89 New areas 425.00 Existing areas

Appendix 4.2—*Contd.*

(1)	(2)	(3)	(4)
25. Gurgaon Canal*	,,	83.6	101.58
Jammu & Kashmir			
26. Tawi Lift Irrigation*	,,	51.7	12.14
Kerala			
27. Malampuzha (1967)	Storage	58.0	38.53
28. Kuttiadi*	,,	52.4	31.16
29. Periyar Valley Scheme* (Bhoothathankettu)	Diversion	64.9	41.00
30. Pamba*	,,	92.1	34.00
31. Kallada*	Storage	144.9	105.22
Madhya Pradesh			
32. Gandhi Sagar Dam (1960)	,,	136.0	222.59
33. Chambal Stage II (Rana Pratap Sagar Dam)	,,	94.0	60.71
34. Tawa Project*	,,	401.5	328.00
35. Barna Project*	,,	70.0	60.29
36. Hasdeo Project*	Diversion	98.6	Supplying cooling water to Korba Thermal Power Station
37. Hasdeo Right Bank Canal*	,,	96.6	47.46
Maharashtra			
38. Ghod Project (1966)	Storage	55.6	24.62
39. Pus River Project (1964)	,,	51.3	11.72
40. Vir Project (1966)	,,	54.1	26.71
41. Purna Project (1968)	,,	160.7	61.51
42. Girna Project (1968)	,,	127.5	57.21
43. Khadakwasla Stage I*	,,	167.0	22.30
44. Mula Project*	,,	161.6	65.56
45. Itiadoh*	,,	69.2	46.14
46. Bagh Project*	,,	58.4	33.67
47. Jayakwadi Project Stage I*	,,	587.8	141.65
48. Bhima Project*	,,	425.8	172.88
49. Warna Project*	,,	310.9	99.06
50. Krishna Project*	,,	276.6	106.29
51. Upper Godavari Project*	,,	142.9	44.27
52. Kukadi Project Stage I*	,,	179.0	42.70
Mysore			
53. Tungabhadra Project (1963)	Storage	680.2	272.10
54. Ghataprabha Stage I (1966)	Diversion	69.3	70.46
55. Bhadra Project*	Storage	350.0	99.02
56. Ghataprabha Stage II*	,,	485.3	46.54
57. Malaprabha Project*	,,	676.5	121.41
58. Kabini Reservoir*	,,	248.0	50.99

Appendix 4.2—*Contd.*

(1)	(2)	(3)	(4)
59. Upper Krishna Stage I*	,,	750.0	242.82
60. Tungabhadra High-level Canal Stage I	Diversion	62.3	40.47
Orissa			
61. Hirakud Project*	Storage	827.6	496.57
62. Salandi Project*	,,	130.8	61.90
63. Mahanadi Delta Irrigation Project*	Diversion	683.8	680.71
Punjab			
64. Harike Project (1958)	,,	91.3	13.80
65. Sirhind Feeder (1960)	,,	67.0	no direct benefit
66. Bhakra Nangal Project (1964)	Storage	1,031.8	(680.00 Haryana 550.00 Punjab 230.00 Rajasthan)
67. Beas Unit I (Beas-Sutlej link)*	,,	1,468.7	530.00 (Punjab and Haryana)
68. Beas Unit II (Pong Dam)*	,,	1,676.7	650.00 (Punjab and Haryana).
Rajasthan			
69. Chambal Project Stage I (Kota Barrage) (1960)	Diversion	217.5	222.00**
70. Ranapratapsagar Dam (Chambal Stage II)*	Storage	278.4	60.70**
71. Rajasthan Canal*	Diversion	1,960.0	1,163.00
Tamil Nadu			
72. Lower Bhavani (1956)	Storage	103.4	78.92
73. Manimuthar Project (1958)	,,	50.5	41.69
74. Parambikulam Aliyar Project*	,,	675.3	97.13
75. Chittar Pattanamkal*	,,	73.3	19.02
76. Modernising Thanjavur Channels*	,,	225.0	57.90
Uttar Pradesh			
77. Matatila Dam (1966)	Storage	124.6	165.76
78. Sarda Sagar Stage II (1966)	,,	73.2	74.93
79. Ramganga River Project*	,,	96.9	659.00
80. Western Gandak Canal Project	Diversion	503.8	264.00
81. Improvement to Lower Sarda Canal*	,,	648.4	607.05
West Bengal			
82. Mayurakshi Dam at Masanjore and Barrage at Tilpara (1956)	Storage	204.6	246.87
83. Kangsabati Reservoir (1965)	,,	460.0	384.47
84. Durgapur Barrage—Improvement and Extension of Irrigation System*	Diversion	188.2 107.1	417.00

*Yet to be completed.

**An equal extent of area will be irrigated in Madhya Pradesh.

APPENDIX 8.1

Districts and Taluks/Tehsils Identified as Drought Affected

I ANDHRA PRADESH

(i) *Anantapur District*
(1) Anantapur
(2) Tadpatri
(3) Dharmavaram
(4) Kalyandurg
(5) Rayadurg
(6) Penukonda
(7) Madakasira
(8) Hindupur
(9) Kadiri
(10) Gooty
(11) Uravakonda

(ii) *Chittoor District*
(12) Chittoor
(13) Chandragiri
(14) Madanapalli
(15) Vayalpad
(16) Pungunur
(17) Palmaner
(18) Kuppam

(iii) *Cuddapah District*
(19) Cuddapah
(20) Kamalapuram
(21) Rayachoti
(22) Rajampet
(23) Badwel
(24) Jammalamadugu
(25) Proddatur
(26) Pulivendla

(iv) *Kurnool District*
(27) Markapur
(28) Kurnool
(29) Dhone
(30) Nandikotkur
(31) Adoni
(32) Aluru
(33) Pattikonda
(34) Koilkuntla
(35) Banganapalli
(36) Allagadda
(37) Giddalur
(38) Atmakur
(39) Nandyal

(v) *Hyderabad District*
(40) Hyderabad (West)
(41) Ibrahimpatnam
(42) Hyderabad (East)
(43) Chevella

(vi) *Mahbubnagar District*
(44) Kalwakurthi
(45) Nagarkurnool
(46) Wanaparthi
(47) Alampur
(48) Makthal
(49) Shadnagar
(50) Achampet
(51) Kollapur
(52) Godwal
(53) Atmakur

(vii) *Nalgonda District*
(54) Suryapet
(55) Bhongir
(56) Hazurnagar
(57) Devarkonda
(58) Miryalguda
(59) Ramannapet
(60) Nalgonda

II GUJARAT

(i) *Banaskantha District*
(1) Santhalpur
(2) Radhanpur
(3) Wao
(4) Tharad
(5) Dhanera

(ii) *Mehsana District*
(6) Harij Mahal
(7) Sami

(8) Chanasma
(9) Patan
(10) Kadi
(11) Kalol

(iii) *Ahmedabad District*
(12) Viramgam
(13) Dhandhuka
(14) Dholka
(15) Sanand

(iv) *Kaira District*
(16) Cambay
(17) Matar
(18) Mehmedabad

(v) *Broach District*
(19) Jambusar
(20) Waghra
(21) Hansot

(vi) *Kutch District*
(22) Anjar
(23) Nakhtrana
(24) Abdasa
(25) Lakhpat
(26) Rahpur
(27) Khavda
(28) Khadir
(29) Mundra
(30) Bhachau
(31) Mandvi
(32) Bhuj

(vii) *Surendranagar District*
(33) Dasada
(34) Wadhvan
(35) Muli
(36) Dhrangadhra
(37) Halvad
(38) Limbdi
(39) Lakhtar
(40) Sayla

(viii) *Jamnagar District*
(41) Okhamandal
(42) Kalyanpur
(43) Jodia
(44) Kalavad

(ix) *Rajkot District*
(45) Malia
(46) Morvi
(47) Wankaner

(x) *Bhavnagar District*
(48) Bhavnagar
(49) Gadhada
(50) Vallabhipur
(51) Botad
(52) Gariadhar
(53) Kundla

(xi) *Amreli District*
(54) Amreli
(55) Khambha
(56) Jafrabad
(57) Rajula
(58) Babra
(59) Lilia
(60) Lathi

III HARYANA

(i) *Gurgaon District*
(1) Rewari
(2) Gurgaon

(ii) *Rohtak District*
(3) Jhajjar

(iii) *Mohindergarh District*
(4) Dadri
(5) Mohindergarh
(6) Narnaul

IV MADHYA PRADESH

(i) *Jhabua District*
(1) Jhabua
(2) Thandla
(3) Patlawad
(4) Jobat
(5) Alirajpur

(ii) *Dhar District*
(6) Dhar
(7) Badnawar
(8) Sardarpur
(9) Kukshi
(10) Manawar
(11) Tappa (Dharampuri)

(iii) *Dewas District*
(12) Bagli

(13) Khategaon

(iv) *Ujjain District*
(14) Khachrod
(15) Ujjain
(16) Tarna

(v) *Khargaon District*
(17) Rajpur
(18) Harwani

(vi) *Khandwa District*
(19) Khandwa
(20) Harsood

(vii) *Datia District*
(21) Datia

(viii) *Shajapur District*
(22) Shajapur

(ix) *Betul District*
(23) Betul
(24) Bhainsadehi

V MAHARASHTRA

(i) *Poona District*
(1) Dhond
(2) Sirur
(3) Indapur
(4) Purandhar
(5) Haweli

(ii) *Ahmednagar District*
(6) Shrigonda
(7) Karjat
(8) Sangamner
(9) Pathardi
(10) Parner
(11) Ahmednagar
(12) Jamkhed

(iii) *Sangli District*
(13) Jath
(14) Khanepur

(iv) *Sholapur District*
(15) Pandharpur
(16) Madha
(17) Mangalvedha
(18) North Sholapur
(19) South Sholapur
(20) Sangola
(21) Karmala
(22) Mohol
(23) Akkalkot
(24) Barshi

(v) *Satara District*
(25) Khandala
(26) Man
(27) Khatav

(vi) *Aurangabad District*
(28) Vaijapur
(29) Gangapur

(vii) *Bhir District*
(30) Ashti
(31) Patoda
(32) Bhir
(33) Georai

(viii) *Osmanabad District*
(34) Parenda
(35) Bhoom
(36) Kalam
(37) Osmanabad

(ix) *Nasik District*
(38) Baglan
(39) Malegaon
(40) Kalwan
(41) Chandor
(42) Nandgaon
(43) Niphad
(44) Yeola
(45) Sinnar

VI MYSORE

(i) *Chitradurga District*
(1) Challakere
(2) Hiriyur
(3) Davangere
(4) Molakalmuru
(5) Jagalur
(6) Hosadurga
(7) Chitradurga
(8) Holalkere

(ii) *Dharwar District*
(9) Ron
(10) Gadag
(11) Ranebennur
(12) Mundargi

(iii) *Bangalore District*
(13) Hoskote
(14) Doddaballapur
(15) Nelamangala
(16) Kanakapura
(17) Magadi
(18) Ramanagaram
(19) Anekal
(20) Devanahally
(21) Channapatna

(iv) *Hassan District*
(22) Channarayapatna
(23) Arsikere
(24) Holenarsipur

(v) *Gulbarga District*
(25) Shahapur
(26) Yadgir
(27) Chincholi
(28) Sedam
(29) Gulbarga
(30) Aland
(31) Afzalpur
(32) Chitapur

(33) Jeevargi
(34) Shorapur

(vi) *Kolar District*
(35) Srinivaspur
(36) Gudibanda
(37) Chickaballapur
(38) Gauribidanur
(39) Bagepally
(40) Kolar
(40) Bangarpet
(42) Chintamani
(43) Mulbagal
(44) Malur

(vii) *Raichur District*
(45) Lingasugur
(46) Deodurga
(47) Yelburga
(48) Kustagi
(49) Koppal

(viii) *Tumkur District*
(50) Madhugiri
(51) Sira
(52) Turuvekere
(53) Tiptur
(54) Kunigal
(55) Pavagada
(56) Chicknaikanahally
(57) Koratagere
(58) Gubbi

(ix) *Bellary District*
(59) Bellary
(60) Siruguppa
(61) Hadagalli
(62) Kudligi
(63) Harapanahalli
(64) Mallapuram
(65) Hospet
(66) Sandur

(x) *Mysore District*
(67) Chamarajanagar
(68) Hunsur
(69) Gundlupet
(70) Nanjangud
(71) T. Narsipur
(72) Peryapatna
(73) Kollegal

(xi) *Mandya District*
(74) Malavalli
(75) K.R. Pet
(76) Nagamangala
(77) Pandavapura

(xii) *Bijapur District*
(78) Bijapur
(79) Indi
(80) Sindgi
(81) Bagewandi
(82) Jamakhandi
(83) Bilgi
(84) Muddebihal
(85) Mudhol
(86) Bagalkot
(87) Hungund
(88) Badami

VII RAJASTHAN

(i) *Jaisalmer District*
- (1) Jaisalmer
- (2) Pokaran

(ii) *Barmer District*
- (3) Barmer
- (4) Shiv
- (5) Pachpadra

(iii) *Jodhpur District*
- (6) Phalodi

(iv) *Churu District*
- (7) Dungargarh

(v) *Bikaner District*
- (8) Bikaner
- (9) Lunkaransar
- (10) Kolayat

(vi) *Ajmer District*
- (11) Ajmer
- (12) Beawar

(vii) *Udaipur District*
- (13) Kherwara

(viii) *Dungarpur District*
- (14) Aspur
- (15) Dungarpur
- (16) Sagwara

(ix) *Banswara District*
- (17) Garhi
- (18) Ghatol
- (19) Bagidora

VIII TAMIL NADU

(i) *Dharmapuri District*
- (1) Hosur
- (2) Krishnagiri
- (3) Harur
- (4) Dharmapuri

(ii) *Salem District*
- (5) Sankari
- (6) Tiruchengode

(iii) *Coimbatore District*
- (7) Dharapuram
- (8) Palladam
- (9) Avanashi

(iv) *Tiruchchirapalli District*
- (10) Perambalur
- (11) Karur
- (12) Kolathur
- (13) Alangudi

(v) *Madurai District*
- (14) Dindigul
- (15) Palani
- (16) Tirumangalam

(vi) *Ramanathapuram District*
- (17) Tiruvadanai
- (18) Paramakudi
- (19) Ramanathapuram
- (20) Mudukulathur
- (21) Aruppukottai
- (22) Sathur

(vii) *Tirunelveli District*
- (23) Koilpatti
- (24) Nanguneri

APPENDIX 8.2

Irrigation Works under construction in Drought Areas

Sl. No.	State/Project	Drought districts which benefit	Continuing from	Irrigation Benefit (000 hectares)
1	2	3	4	5
	ANDHRA PRADESH			
1.	Nagarjunasagar	Nalgonda & Kurnool	I Plan	829.64
2.	Musi	Nalgonda	,,	16.92
3.	Tungabhadra H.L. Canal Stage I	Anantapur & Cuddapah	II Plan	48.21
4.	Tungabhadra H.L. Canal Stage II	Kurnool, Bellary, Cuddapah & Anantapur	Annual Plans	55.62
5.	Rajolibanda Diversion	Mahbubnagar	I Plan	35.61
6.	Okachetti Vagu	,,	Annual Plans	2.71
7.	Gajuladinne	Kurnool	Annual Plans	5.06
8.	Kotepalli Vagu	Hyderabad	III Plan	4.04
9.	Kanupur Canal	Nellore	,,	6.89
10.	Gandipalem	,,	Annual Plans	4.05
11.	Bahuda Reservoir	Chittoor	Annual Plans	1.17
	GUJARAT			
1.	Narmada	Broach & Baroda	II Plan	403.69
2.	Mahi Stage I	Kaira and Panchmahal	I Plan	186.16
3.	Mahi Stage II		II Plan	16.55
4.	Saraswati	Mehsana	,,	8.74
5.	Dhatarwadi	Amreli	,,	2.43
6.	Goma	Bhavnagar	,,	2.19
7.	Machhu II	Rajkot	,,	7.69
8.	Rudramata	Kutch	I Plan	7.20
9.	Ganjansar	,,	II Plan	1.62
	HARYANA			
1.	Gurgaon Canal	Gurgaon	II Plan	101.50
2.	Rewari Lift Irrigation	Gurgaon, Rohtak and Mohindergarh	,,	27.82

Appendix 8.2—*Contd.*

1	2	3	4	5
	MADHYA PRADESH			
1.	Borad (Setak & Segwal)	Khargaon	I Plan	5.06
2.	Chandrakeshar	Dewas	II Plan	4.86
3.	Bhehsakhedi	Ujjain	,,	1.39
4.	Pampavati	Jhabua	,,	1.09
	MAHARASHTRA			
1.	Mula	Ahmednagar	II Plan	65.56
2.	Adula	,,	Annual Plans	5.75
3.	Kukadi Stage I	Ahmednagar & Poona	,,	42.70
4.	Khadakwasla Stage I	Poona	II Plan	22.30
5.	Bhima Irrigation	Poona & Sholapur	Annual Plans	172.89
6.	Padwal-Karwadi	Sholapur	,,	0.83
7.	Upper Godavari	Nasik	,,	44.27
8.	Chankapur Dam	,,	,,	12.04
9.	Jayakwadi Stage I	Aurangabad & Bhir	,,	141.65
10.	Warna	Sangli	,,	99.06
11.	Kadi	Bhir	,,	1.10
12.	Krishna Irrigation	Satara, Sangli	,,	106.29
	MYSORE			
1.	Hathikoni Dam	Gulbarga	I Plan	2.14
2.	Upper Krishna Stage I	Bijapur, Raichur & Gulbarga	III Plan	242.82
3.	Rajolibanda Diversion	Raichur	I Plan	2.38
4.	Kanakanala	,,	II Plan	2.06
5.	Tungabhadra High Level Canal Stages I & II	Bellary	I Plan/ Annual Plans	80.94
6.	Hagaribommanahalli	,,	II Plan	2.97
7.	Kabini	Mysore	,,	50.99
8.	Chickhole	,,	,,	1.60
9.	Hebbahalla	,,	,,	1.21
10.	Arakavathy	Bangalore	Annual Plans	2.83
11.	Hemavati	Hassan & Mandya	—	
12.	Chandrampalli	Gulbarga	—	5.00

Appendix 8.2—*Contd.*

1	2	3	4	5
	RAJASTHAN			
1.	Rajasthan Canal	Bikaner & Jaisalmer	II Plan	1263.00
2.	Mahi (Banswara)	Banswara	—	30.75
3.	Lasaria	Ajmer	Annual Plans	1.62
4.	Berch	Udaipur	II Plan	3.24
5.	Sei Diversion	,,	Annual Plans	9.02
6.	Khari Feeder	,,	II Plan	3.24
7.	Jakham Part II	,,	Annual Plans	11.65
	TAMIL NADU			
1.	Parambikulam-Aliyar	Coimbatore	II Plan	97.13
2.	Modernising Vaigai Channels	Madurai & Ramanathapuram	Annual Plans	44.42
3.	Gatana Reservoir	Tirunelveli	,,	3.29
4.	Ramanadhi	,,	,,	1.41

APPENDIX 16.1

Irrigation Acts and Codes

ANDHRA PRADESH

1. Andhra Pradesh (Andhra Area) Irrigation Act, 24 of 1357 F.
2. Andhra Pradesh (Andhra Area) Canals and Public Ferries Act, 2 of 1890.
3. Andhra Pradesh (Andhra Area) Irrigation Cess Act, 7 of 1865.
4. Andhra Pradesh (Andhra Area) Irrigation Works (Repairs, Improvement and Construction) Act, 18 of 1943.
5. Andhra Pradesh (Andhra Area) Irrigation Tanks (Improvement) Act, 19 of 1949.
6. Andhra Pradesh (Andhra Area) Land Improvement Schemes (Contour Bunding and Contour Trenching) Act, 22 of 1949.
7. Andhra Pradesh (Andhra Area) Irrigation Works (Levy of Compulsory Water-Cess) Act, 24 of 1955.
8. Andhra Pradesh (Andhra Area) Rivers Conservancy Act, 6 of 1884.
9. Andhra Pradesh (Andhra Area) (Levy of Betterment Contribution) Act, 25 of 1955.
10. Andhra Pradesh Irrigation (Construction and Maintenance of Water Courses) Act, 1969.
11. Hyderabad Irrigation (Betterment Contribution and Inclusion Fees) Act, 5 of 1952.

ASSAM

1. Assam Betterment Fee and Mooring Tax (Dibrugarh) Act, XII of 1953.
2. Assam Embankments and Drainage Act, 1 of 1954.

BIHAR

1. The Bihar Irrigation Field Channels Act, 1965.
2. Jharia Water-Supply Act, 3 of 1914.
3. Bihar Irrigation and Flood Protection (Betterment Contribution) Act, 28 of 1959.
4. Bihar Lift Irrigation Act, 16 of 1956.
5. Bihar Public Irrigation & Drainage Works, Act, 10 of 1947.
6. Bihar Private Irrigation Works Act, 5 of 1922.
7. Bengal Irrigation Act, 3 of 1876.
8. Bihar Emergency Cultivation and Irrigation Act, 22 of 1955.
9. Bengal Canals Act, 5 of 1864.
10. Bengal Embankment Act, II of 1882.

HIMACHAL PRADESH

1. Himachal Pradesh Minor Canals Act, 1968.

JAMMU & KASHMIR

1. J. & K. Government Aid to Agriculturists and Land Improvement Act, VII of 1993. (1936 A.D.).
2. Kashmir Valley Embankment Act, VII of 1992 (1935 A.D.).
3. J. & K. State Canal & Drainage Act, 1963.

KERALA

1. Kerala Land Development Act, 1964.
2. Kerala Irrigation Works (Extension of Joint Labour) Act, 1967.
3. Irrigation Tanks (Preservation and Improvement) Act, 23 of 1952.
4. Public Canals & Public Ferries Act, 1096.
5. Madras Irrigation Works (Repairs, Improvement and Construction) Act, Mad.18 of 1943.
6. Irrigation (Levy of Betterment Constribution) Act, Mad. 3 of 1956.
7. Irrigation (Voluntary Cess) Act, Mad. 13 of 1942.
8. Irrigation Tanks (Improvement) Act, Mad. 19 of 1949.
9. Irrigation (Construction and Levy of Cess) Act, Mad. 7 of 1947.
10. Irrigation Act, T. C. 7 of 1956.

MADHYA PRADESH

1. Land Improvement Schemes Act, 10 of 1958.
2. M.P. Irrigation Act, 14 of 1931.

MAHARASHTRA & GUJARAT

1. Bombay Irrigation Act, 7 of 1879.
2. Bombay Land Improvement Schemes Act, 28 of 1942.

MYSORE

1. Mysore Irrigation Act, 1965.
2. Mysore Irrigation (Levy of Betterment Contribution and Water Rates) Act, 1957.

ORISSA

1. Orissa Betterment Charges Act, II of 1956.
2. Orissa Irrigation Act, 14 of 1959.

PUNJAB

1. Northern India Canal and Drainage Act, 8 of 1873.
2. Punjab Betterment Charges and Acreage Rates Act, 2 of 1953.
3. Punjab Minor Canals Act, 3 of 1905.

RAJASTHAN

1. Rajasthan Lands Special Irrigation Charges Act, 23 of 1953.
2. Rajasthan Irrigation and Drainage Act, 21 of 1954.
3. Rajasthan Minor Irrigation Works Act, 12 of 1953.

TAMIL NADU

1. Madras Irrigation Cess Act, 7 of 1865.
2. Madras (Additional Assessment and Additional Water-Cess) Act, VIII of 1963.
3. Madras Irrigation (Voluntary Cess) Act, 13 of 1942.

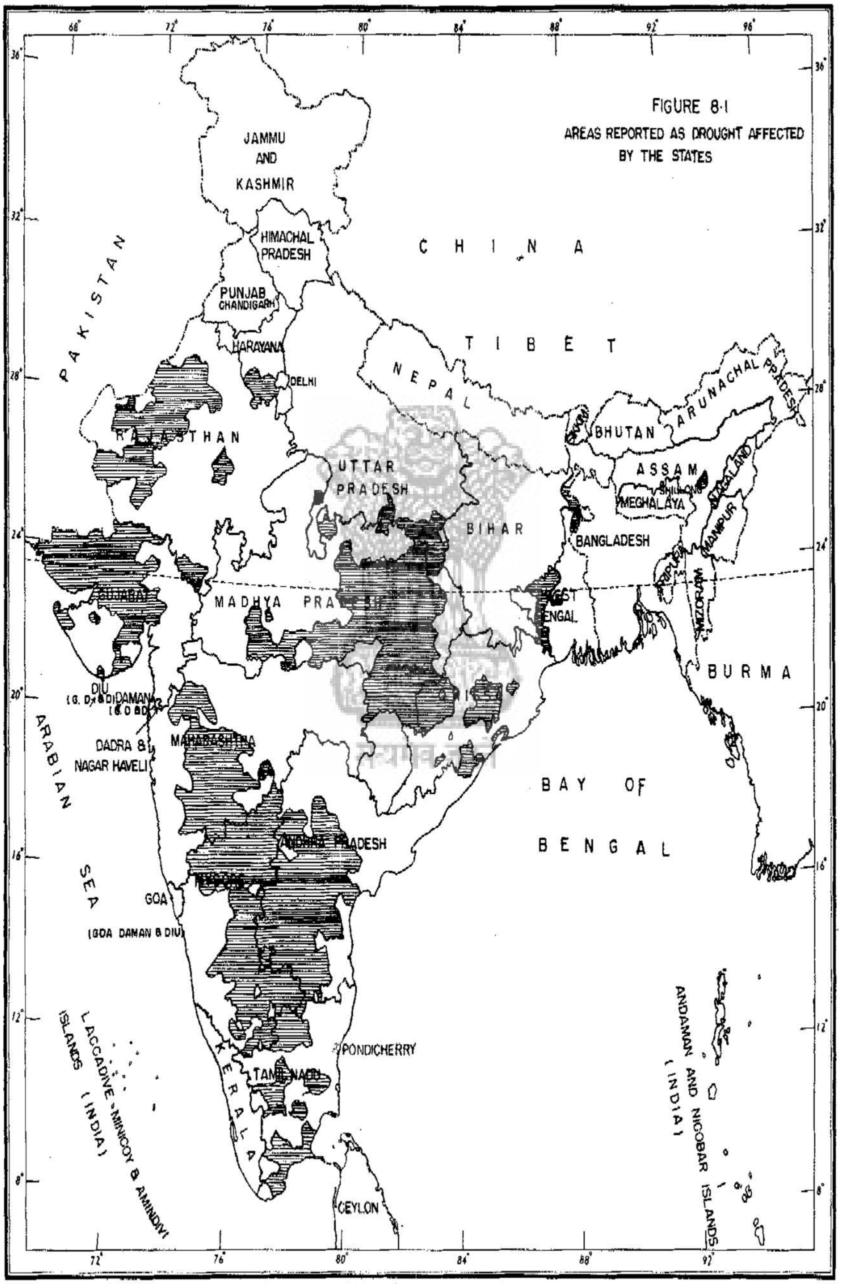
4. Bhavani Reservoir Irrigation Cess Act, 16 of 1933.
5. Madras Irrigation (Levy of Betterment Contribution) Act, 3 of 1955.
6. Malabar Irrigation (Construction and Levy of Cess) Act, Mad. 7 of 1947.
7. Mettur Canal Irrigation Cess Act, 17 of 1953.
8. Madras Irrigation Works (Repairs, Improvement & Construction) Act, XVIII of 1943.
9. Madras Land Improvement Schemes Act, XXXI of 1959.
10. Madras Irrigation Tanks (Improvement) Act, XIX of 1949.
11. Madras Irrigation Works (Construction of Field Bothies) Act, XXV of 1959.
12. Periyar Irrigation Tanks (Preservation) Act, V of 1934.

UTTAR PRADESH

1. Northern India Canal & Drainage Act, VIII of 1873.
2. United Provinces Private Irrigation Works Act, 2 of 1920.
3. United Provinces State Tubewells Act, 12 of 1936.
4. Minor Irrigation Works Act, 1 of 1920.

WEST BENGAL

1. Bengal Irrigation Act, 3 of 1876.
2. Canals Act, 5 of 1864.
3. West Bengal Irrigation (Imposition of Water-Rates for Damodar Valley Corporation Water) Act, 25 of 1959.
4. West Bengal Closing of Canals Act, 2 of 1959.
5. Bengal Tanks Improvement Act, 15 of 1939.
6. Bengal Development Act, 16 of 1935.



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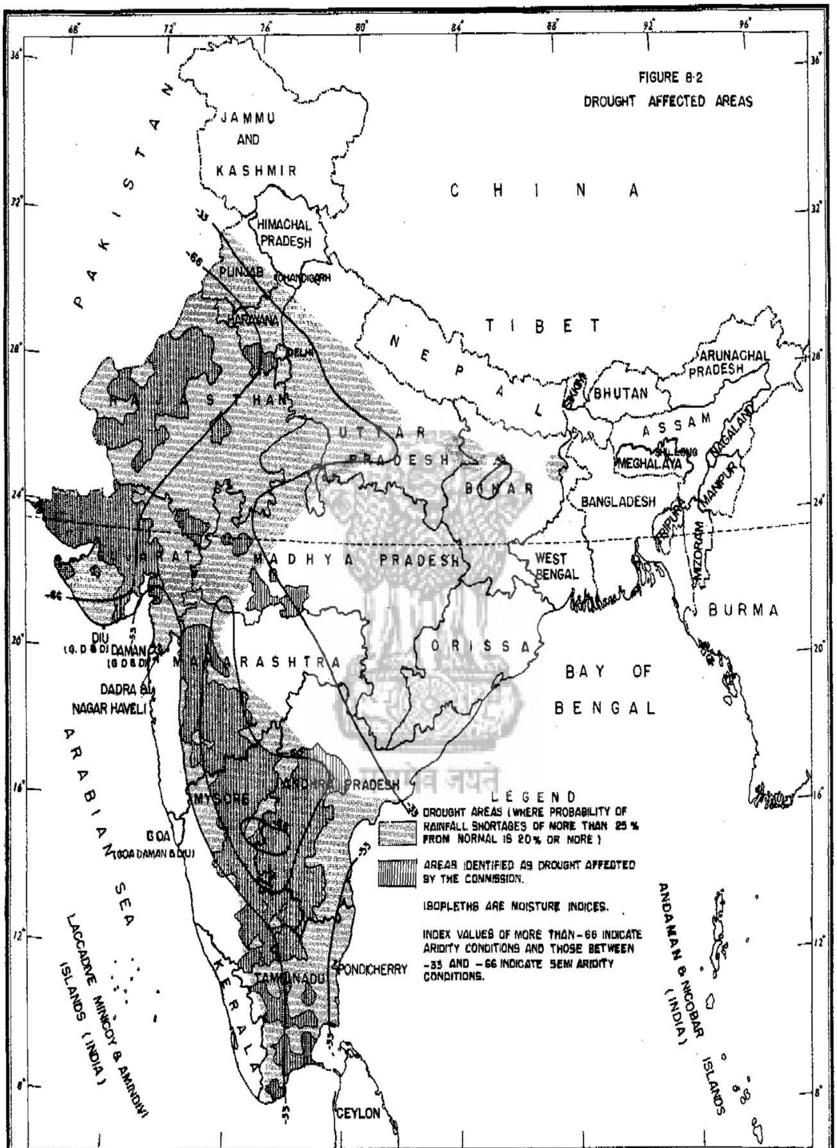

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